Lane Community College - Study Tips

Study Tip #1 – Some Basic Study Methods

Outline of Basic Study Methods

1. Always build firm associations.
2. Set conscious learning goals.
3. Find what is important.
4. Work to understand it.
5. Work to build memory.
6. Distinguish declarative from procedural knowledge and study them differently.
7. Test yourself to know when you've got it.
8. Pay attention.
9. Space out study sessions on the same topic.

Always build firm associations.

To learn is to build firm associations. When you build strong associations between things, you will be able to remember them. Your memory will be poor if you take in information without understanding it by associating to its meanings or without understanding its relationship to bigger pictures, examples, details and so on. And your memory will also be poor if you make weak and fragile associations to new information. So as you listen, read, study and practice things, keep noticing how the information and actions relate to other things.

Pay attention.

When you read or listen or practice or take in information in any way, pay attention to the incoming information and its meaning. Attention leads to memory because your unified focus brings more mental resources to bear on the topic and strengthens associations. Distraction and divided attention weaken memory because your mind's strength of focus weakens as it is spread out. Paying attention is a very simple and powerful way to study. It is one of the few study strategies you can use that does not require extra time.

When you notice your mind has wandered, bring it back to the topic and do so gently. Do not criticize yourself for being distracted. Why not? Negative thoughts will call to mind other negative memories and waste time and make bad associations.

Set conscious learning goals.

People who set specific and conscious goals to learn usually learn much more while they read, study and practice than do people who just "do the assignment".

- The reason? What we **want** while we study affects what we **do**. And what we **do** while we study creates what we **get** as learning results.
- When you have set specific goals, then you can test yourself and find out how well you did. Without goals you cannot know your progress. And general goals are too fuzzy to help.
- Where do you get your goals? The first goal is build strong associations to what you are learning. Identify what your instructor wants you to learn and set that as a major goal. Also set your own learning goals.

- Make yourself turn alive to goals by asking questions, which are mini-goals. Wanting to know the answer to a question and then finding information that is an answer to it will build an association between question and answer. Or say to yourself, "I wonder . . ." Wondering and then finding ideas and experiences that relate to our wonder-ing also creates associations. Your listening and reading will feel different–more alive and alert–when you question, wonder and search for something.
- When you are just beginning to study brand-new topics, set low sub-goals for that day's studying. Permit yourself to make weak associations. Later, when you are in the middle phases of studying, set higher sub-goals. Build strong associations that survive long time gaps between study and self-test.
- Beware of goals that prevent learning. Many students want to get done fast, to avoid a disliked subject, to be per-fect with no mistakes, or to look smart to other people. When you work for these goals, you will neglect true methods of learning.

Find what is important.

Not everything you read and see and hear is important. Since you are not required to remember literally everything, you can save time studying by choosing the important things to focus your learning time on.

- What is important? I can't give a general answer that would cover the great diversity of courses. Here are some common categories: basic information and facts in a field; concepts and the major facts that fit into the concepts; sets of concepts that are organized into schemas or frames of reference; major generalizations about causes and ef-fects; evidence in support of the big ideas; in literature both the specific events and general patterns in a work; in history the big ideas and specific facts; in skill courses the instructions on how to do the steps in a procedure and the worked examples showing how to do it.
- When you find something important in a class lecture, take notes on it. When you find important ideas in reading, mark their location so that when you review, your eye will be drawn to the important and you can skip the minor. It wastes your time to find what's important on Tuesday and to miss it when you review on Thursday.

Work to understand what you hear and read.

To understand means to be able to associate a bit of information to its meaning and to its relationship with many other concepts and facts. Our level of understanding of information can vary from non-existent to shallow to deep. It is much more useful to understand knowledge than to know it by rote.

- Why understand? Since there are many parts in any field of knowledge, you will make mistakes if you do not understand it. Also, research on memory shows that we can more easily recall understood material than not-understood material.
- Starting with the simplest level of understanding, know the meaning of the words in what you read. When words puzzle you, do what is appropriate to figure them out: look up words, use the context to infer the meanings, look behind and ahead to get clues, make mental images of what is said, break things apart in charts with arrows to show relationships.
- Choose a reading speed that is slow enough to give your mind time to look up the meanings of words. Why? Because it takes time for your mind to travel along the paths associating a word to its meanings and to report the information back to your conscious mind. Focus your attention on the meanings flowing into your mind and use them as feedback to your reading speed. Warning: Our minds send a signal that we *recognize* a word about 0.2 seconds after we see it, but we get the *meaning* of a word about 0.3 to 0.6 seconds after we see it. Don't use that 0.2-second signal of recognition as feedback for your reading speed.
- Expect to read more slowly when you read rare words, artificial symbols (math, physics, chemistry), tightly logical arguments, and very new topics. It takes longer to make associations to such difficult information. If you are a fast reader, your learning is at risk unless you catch these signs of difficulty and slow down.
- Stop briefly after a complex phrase, sentence or paragraph. Give yourself one or two seconds of blank time so that your mind can bring the separate parts of a passage together and make associations. Research shows these little stops improve understanding.
- At the level of paragraphs and short passages, know the larger story these units tell. When puzzled, make explanations for yourself. Here is how: Take one sentence and then talk aloud to yourself and translate it into your own words. Do it for a series of sentences. As you get a few sentences translated, then explain to yourself how they are related to each other. Each of these translations makes associations that make memories.

- When your social situation stops you from talking aloud, do anything you can to make your thinking clear, because it will strengthen associations. Write notes or talk in your mind in words.

Work several ways to build memory.

When you understand a topic, you will develop some memory naturally. Understanding develops memory because it makes strong impressions of the knowledge and associates it to things we know already. Understanding, however, is not enough to build all the needed memory, by itself, because we cannot recall all information that we understood when we heard or read it. Be prepared to intentionally review and memorize. Later Study Tips in this series will give details on the following suggestions.

- When the text is written awkwardly, break sentences into small chunks and learn the chunks separately. Changing chunk size is very helpful.
- When you see related information spread across several sentences, bring it together into one chunk and study the larger chunks. Example: An economics book might state in one sentence a cause such as high unemployment and wait until later to state several effects such as people's poverty, hunger, and migration to other areas. Making chunks larger is a powerful way to improve learning. Group things.
- Study the information in detail. Let it make a strong and clear impression on your mind. Avoid fuzziness when possible.
- Associate other ideas, facts, and feelings to information. Mental elaboration builds memory.
- Intentionally memorize important information. Use look-away methods. Use self-tests.

Distinguish declarative knowledge from procedural knowledge or skills and study them differently.

- Declarative knowledge means "knowing that" something is so, knowing things you can explicitly talk about. Examples: "It rains about 40 inches a year in Eugene, Oregon." "Herbivores are animals who eat only or mostly plants." Study by getting understanding and making associations.
- Procedural knowledge is where we "know how" to do something to get a result. Examples: Having accuracy and speed in reading, keyboarding, playing a sport, playing a musical instrument, solving problems in math, writing an essay, and choosing the right words to say in emotional situations. To study: break procedures down into separate steps; break steps down into each one's goals, situations and actions. Practice, practice! All of these actions make memories firm.
- When studying plan to notice which kind of knowledge you are dealing with. You will study them in somewhat different ways. See other study tips in this series for more details on learning declarative and procedural knowledge.

Test yourself so that you know when you've got it.

Research on learning shows that one of the most powerful learning methods is doing the kind of self-tests that give you feedback and correction. Self-tests help two ways: (1) They show you what you know and don't know, and (2) they build memory themselves by associating questions to answers (declarative knowledge) and by running through the steps of a skill and building memory of the experience (procedural knowledge).

- Test your declarative knowledge by asking yourself the important questions and stating the answers. If you use the look-away learning methods, you will be automatically doing self-tests.
- Test your procedural knowledge by doing tasks, problems, and skills. Using the goals that are appropriate for your phase of learning, notice how accurate and fast you are.

Use spaced learning methods.

Spaced learning means studying the same topic several times in separated sessions. By running through the informa-tion several times, you review similar associations and make new ones; it will strengthen your knowledge. Extensive research on many subjects shows that spaced study increases learning more than massed study does. You can preview and review; you can study several times. Avoid massed cram sessions.

Study Tip #2 - READING TO UNDERSTAND

Outline of Reading to Understand:

- Understanding builds associations and memory.
- Preview chapters.
- First reading: Read for the meaning and to find and mark what is important.
- Read things twice.
- Second reading: deal with difficult passages.
- Second reading: Plug ideas into mental frameworks.
- Second reading: Translate the words into other mental representations.
- Second reading: Break large chunks into small chunks. Group small chunks together into larger chunks.
- Second reading: Pull together the five aspects of definitions of concepts.
- Second reading: Track sets of concepts and examples.

Understanding builds associations and memory.

People normally will remember ideas better when they understand them than when they don't because to understand means to associate an idea and its meanings together. So any methods you use to understand what you read will improve your learning. Using a method of getting understanding takes more reading and thinking time at first, but it pays you back later with better memory. If you do not have much time to use the techniques described below and need just one method, then pay close attention to the meaning of what you read. Attention is vital.

Preview chapters.

Search for information that tells you a lot about what you will find in the chapter. Try to find these things: the learning goals; the topics discussed; some of the concepts and theories; the claims the author makes; and the overall structure.

- Good material can be found in introductions, summaries, boldface headings, and topic sentences. Do not read everything, instead hunt for the high points, the big ideas.
- Doing previews before you read will give you an early framework to associate the detailed ideas with as you read. You probably will not be able to keep the framework consciously in mind while you read for the first time because it is all too new for you. But it will boost understanding and memory. Any little bit helps.
- Don't make the mistake of doing previews too fast because high speed scanning does not give you enough time to notice the meanings that come to mind as you preview. When you find a big idea, pause and think over its meanings.

First reading: Read for the meaning and to find and mark what is important.

- Set one goal during your first reading: to understand the meaning. Notice what the sentences mean. When time is short, do not set only the goal of getting through the material quickly, because then you will sacrifice meaning and waste your own time.
- If you cannot get it the first time, mark a **?** in the margin so that you can return to it later.
- Set a second goal to find and mark important things. Why? To save time reviewing. When you come back to study a book, you can save hours of reading time by going right to the passages you marked and studying them.
- Pay attention as you read. When your mind wanders, bring it back to the subject a few words before where you were when your attention shifted. Reason: Our attention is needed for our minds to activate and notice the meanings of words, phrases and sentences. Our attention adds force to learning, improves memory, and saves study time.
- Choose a speed of reading that is slow enough for you to notice the meanings coming into your conscious mind. When you notice that you did not know exactly what something meant, slow down and repeat reading it. To consciously remember the meaning later you need to consciously pay attention when you read it.
- You will be associating the words on the page with your own mental images and knowledge and with what you recall from your preview.

- Pause for a second at the end of a complex sentence, paragraph, or section and notice the overall meaning a little longer. Most people don't stop. Understanding grows with little pauses because your mind pulls separated ideas together.
- When your author provides diagrams, charts, graphs, tables, and illustrations, set your goal to understand them, too, by figuring out what they mean. When a graphic relates to principles or facts described in the text, pay conscious attention to how each verbal part of the written information relates to each visual part of the graphic. Doing so will build your memory.

Read things twice.

You will get many benefits by reading and studying material two or more times. If you have never done it, I recommend you experiment with it and notice the changes in your understanding and memory.

- Bad things happen to memory when we read textbooks just once. Since we usually find that texts have reasonably new and complex ideas, we only understand some of them on our first reading. We miss many patterns and links among ideas. But our reading a second time permits us to see the author's structure.
- When we read the first time, it can be hard enough to figure out the words and the intended meaning of the author. Our working memory doesn't have enough "mental space" to also notice how details fit into big ideas. But on the second reading, now that we understand simple meanings, it gets easier to see more complex meanings and see parts grouped in various ways.
- Try to do your second reading within a day or two. If you delay too long, the strength of your associations will have weakened, and you'll forget too much and have to reteach yourself things.

Second reading: deal with difficult passages.

There are several special techniques you can use to clear up difficult passages.

- **Find the kinds of information that lack meaning** to you because they are usually more difficult than others.
- Examples are symbols, numbers, new words, foreign words, people's names, and facts that seem arbitrary with no apparent explanation. They are difficult because when the author uses a symbol or name the next time, you may have already forgotten it and that will make it harder to understand the passage.
- **Mark or take notes** on low-meaning material.
- **You may want to prevent difficulty** by memorizing low-meaning material soon after you read it so that you can follow the book. If you cannot write it down, make notes and keep them with you as read later material that uses earlier material. By learning vocabulary you will be able to make associations more easily to later passages that uses those words. The same goes for numbers, names and arbitrary facts.
- **Make self-explanations** on any passages you find complex and difficult. Your goal is make your mental model match up with the author's mental model. Go line by line and talk to yourself about what it means. Try to think of what the section means in terms of what you already know. If the author says something that seems not to make sense, then keep working at it.

Second reading: Plug ideas into mental frameworks.

A mental framework is a "big idea", a set of general ideas that applies to a lot of specific information. Associate bits of new information to sets of big ideas by consciously noticing how the new ideas fit into them.

- Keep the frameworks consciously in your mind on your second reading, and figure out how other facts and ideas fit into them. As you do, your understanding will grow.
- Use the author's frameworks.
- Use common general frameworks.
    - Time – before and after.
    - Space – locations and relationships.
    - An object and its description.
    - A whole thing – parts and organization.
    - Causes and effects.

    - Means and goals.
    - Concepts and their relationships.
- Go outside the boundaries of sentences to organize ideas into frameworks. You will have to link ideas and concepts that occur over gaps of several sentences or even several pages. For example, sometimes a cause is discussed in one sentence, and its effect in a later sentence. Or a whole and its parts will cover pages and pages. You must catch such a spread of ideas.

Second reading: Translate the words into other mental representations.

- A representation means the way your mind makes images of the information—visual, auditory, kinesthetic, stories, analogies, languages, etc. When you add one or two more representations to the original words, your understanding will get deeper because you are associating two representations together.

- **Visual representations:** Turn the sentences into mental pictures of objects and their locations and movements.
- **Auditory representations:** (1) Imagine how events described in the passage sounded, what noises there were. (2) Imagine hearing the passage read aloud to you in the voice of someone you know. Imagine their intonation and rhythms. Why do this? When silent reading doesn't seem to make sense, hearing it often does. And, oddly, people who can imagine hearing a familiar voice reading it can improve their understanding.
- **Kinesthetic representations:** Imagine going through the movements involved as if you were living through a process or events. One electronics major puzzled by a circuit diagram imagined he was an electron going through the circuit, and suddenly he understood it. Math majors move their hands to mimic curves on graphs. Many people imagine how things feel to the touch. Athletes often find that they learn abstract information better when they turn it into kinesthetic representations. Their understanding improves.
- **Stories and personal experiences:** Take information and make up stories that put the ideas together. For example, student nurses can read about a disease and its treatment and make up a story about working with a friend who is sick.

Second reading: Break large chunks into small chunks. Group small chunks together into larger chunks.

Although in relaxed reading we accept the phrases and sentences an author gives us as being the natural chunks, we can often do better than the author in breaking up the chunks and give ourselves better understanding. Each time you create new chunks, you create new ways to associate the parts of the information to each other.

- Break complex sentences into short simple chunks. Try to understand one part, then another part and a third. Finally, put them together.
- Assemble chunks together into larger patterns and try to understand the larger pattern.
- Play with chunks in various representations: visual, auditory, kinesthetic, and stories.
- Play with chunks in the common general frameworks mentioned earlier.

Second reading: Pull together the five aspects of definitions of concepts.

When authors define new concepts, they often spread five things over several paragraphs. They are: the word itself, its verbal meaning, some positive examples, negative examples, and prototype examples. Science texts often add measurement.

- The verbal meaning is normally what we mean by "definition", and it is often abstract.
- A positive example is a specific instance of the concept. A positive example of a mammal is a cow. Often writers will give several positive examples of a concept in order to help students apply the idea to the full range of phenomena that the concept and its word refer to. Thus authors will point out other mammals like whales and kangaroos (yes, marsupials are mammals).
- Negative examples are instances that don't fit into the concept but might be confused with it. Take the concept of birds. We think of flying things but negative examples of birds are bats, flies and wasps.
- Prototype examples are useful typical examples of the concept and are especially helpful to memorize in visual form to help recall the concept. When stuck for a definition one recalls a prototype. For example, one

math teacher taught his students a prototype problem of percentage calculations, so that if they were stuck later, they could recall the prototype and use it as a model to figure out the new problem.
- Measurement means the units like mass, velocity, size, birth rates, growth rates.
- When you learn new words and study them, gather together all these aspects of new concepts and watch your memory grow.

Second reading: Track sets of related concepts and examples.

Most authors spread out their discussions of related concepts over several pages. Ideas that are spread out are sometimes hard to make associations between because we may not to notice how they are linked. Therefore, trace them and see their relationships.

For example, imagine an article about birth rates of deer in a certain environment. "Birth rate" is a concept. One doe's act of giving birth is a part of the idea. All the births in a year for all deer in an area are also part of the idea. The number of births per thousand deer in a year is a birth rate. Then the rates over several years can be listed in a table. A graph can be made of birth rates. Finally, a formula linking birth rates to population size might be presented. You would find such information spread over many pages. By gathering it together, you will understand it better.

Study Tip #3 - USING MENTAL FRAMEWORKS TO LEARN MORE

Introduction and examples of frameworks

Educational researchers have found a powerful technique students can use to understand and remember more: **Plug new ideas into familiar frameworks**. A framework is a general body of knowledge about a topic. It contains attributes of the topic, and attributes can vary from case to case. For example, people's knowledge of baseball rules [each rule is an attribute] contains general knowledge of how events can vary in games. When a person watches a player catch a fly ball and interprets what happens as an "out", that viewer has used an association to interpret the game, and if the person associates that fly ball and out to other events in the game, he or she may remember the event much later. Plugging ideas and events into familiar frameworks is a powerful way of making associations, which is a fundamental principle of memory.
As you read the following examples, notice how the use of organizing frameworks helped people learn more easily.

- Researchers improved U.S. history textbooks for middle school children by teaching them "big ideas". For example, they taught them that human problems in history led to solutions and these solutions in turn caused problems and led to more effects. Children studying with this familiar big idea in mind both understood history better and remembered more. By reading historical events and thinking of this big idea, they associated the events to the framework of a series of problems, solutions, more problems, and more solutions.
- Researchers studying ways to present material in textbooks discovered that when they organized information in tables and charts, people learned better than when they presented information in ordinary outlines. Students found there was something about seeing concepts and ideas neatly according to their place in a framework and displayed in rows and columns that improved learning. Students who create charts to their own notes learn better, too. Any organization helps make mental associations and spatial arrangements of notes works well.
- Researchers studying memory have discovered that when people have to learn many related terms, like the names of rocks and minerals in geology, they can remember more if they see the contents organized in charts rather than in lists or unorganized charts. Charts create an organization and make association easy.
- Researchers have discovered that if they tell the story of a baseball game to people who already understand baseball rules and how typical games go (a framework), such people have a good memory for the stories. In contrast, people who don't know baseball forget more. This advantage for knowing frameworks occurs on most topics on which people already have a body of knowledge. The more we know, the more rapidly we learn. The more associations we already have, the easier it is to make new associations.
- The writers of a difficult chapter in a certain biology text had to solve the problem of describing 19 parts of cells clearly. They solved it 3 ways: They made a table and grouped the summary information under the headings of structure (the 19 parts), function (what they did), and composition (what they were made of). They also drew diagrams labelling the parts in the cells. And they linked the parts as they wrote the descriptions by describing the flow of stuff that the cells made and how the flow goes from part to part. The

resulting frameworks helped readers bring order out of complex and very unfamiliar material and made it easier for them to associate the parts of the information together and remember it.

- Yet certain frameworks are bad for learning! Researchers have discovered that when teachers and writers tell interesting stories and odd but irrelevant facts, unfortunately students' learning drops. And when the irrelevant facts are told at the beginning of a lecture, the damage is worse. Why? Because students use these irrelevant frameworks to organize the material around, and such associations are not the ones they will encounter as test questions.
- Each of these methods involves building frameworks that give **general summaries** that help the reader understand different kinds of **specific information**. Each **framework** has **parts** that are **linked** together. When we learn new facts, we will fit them somewhere in the frame. We do not have to learn thousands of facts as unrelated items, but can associate each new fact to its classification within the frame.

Tips on using frameworks in reading.

- When you read difficult new material for the very first time, you don't need to think about frames unless good writing makes it easy. You will often find it best just to read for ordinary understanding the first time. But on your second reading, then you should link new information to parts of frameworks.
- Do search for frameworks. You will often find them in headlines, section headings, summaries, charts, diagrams, flow charts, general principles. You will also see them in introductions or in the topic sentences of paragraphs. And look for them in analogies, similes and metaphors.
- When you study information, study the bits of information in pairs: (1) a specific fact or concept and (2) what part of a framework it fits.
- Study in little cycles: look at the book, then stop and look inward and link an idea to a place in a framework. Read and link, read and link. Stop after finding new facts or concepts and think which part of the framework the new information fits into. Link facts to categories in frameworks one by one. Doing this will require you to practice changing your normal behavior because most of us just read steadily without stopping to think. Change! It's important!
- Link important concepts and ideas with several frameworks, because when we can associate new material to several things our memory goes up.
- Use visual and spatial imagery as frameworks to organize new information. Make mental pictures of ideas. Research shows that linking information to visual frameworks is very powerful; it usually beats learning in words. Try to visualize the new information.
- Combine both visual and verbal information in the same framework. Charts and graphs do that. When the authors give charts which arrange ideas in rows and columns to see, use them carefully. When you have no charts available, make your own charts and diagrams that show relationships.
- Use your body movements as a framework. When you read about doing procedures, you can imagine moving your hands or legs. Movements make good frameworks.
- When you recall a personal experience similar to new knowledge, use your experience as a framework and interpret the new ideas in terms of it.
- Use the parts of frameworks as a source for questions to test yourself with. You may already be aware that asking and answering questions about the material is a very powerful way to study. You can make it even more powerful by using a part of a framework as the question and using the new information as the answer, or vice versa.
- Learning the steps in cognitive skills is different from learning ordinary knowledge. A useful framework is to identify the steps; then identify each step's **goal**, the **situation** it applies to and the**action** to do. (See the study tips on learning skills for details.)

Handling the problem of learning both the framework and information at the same time.

Suppose you have the task of learning both new information and new frameworks at the same time. How do you do it?

When everything is new to you, set as your goal to create rapidly both a core of familiar frameworks and a core of well-learned facts. These two memorized cores are not meant to cover everything in the material. Their purpose is to give you very meaningful information you can use to associate new information to.

Try these tricks:

- Ask your teacher to identify the "big ideas".
- Put your most intense studying efforts into the first few days of these difficult units. It will pay off later in more relaxed studying.
- Learn the vocabulary and basic facts very fully. Review repeatedly, use flash cards, test yourself, and practice so that you have a solid core.
- As you identify assumptions, basic patterns and principles, and organizing ideas, write them down and practice them. These are mini-frameworks.
- Then link new facts to the new frameworks.

Handling the problem of missing frameworks with six useful frameworks:

Sometimes you won't be able to find good frameworks in the books or articles you read. When that happens, you can use these important general frameworks. They apply to many topics.

- **Time: Before and after.** Organize things you read about in a series by what comes first, second, third. As you become conscious of time order, your memory will go up.
- **Cause-and-effect.** Many things cause or influence other things to happen. To say "cause" does not mean that something is the only cause of another event, just that it affects or influences the second thing. If you use your mind to classify events as causes and effects, your learning will improve.
- **Wholes and parts.** Authors often describe the parts that something is made of and how the parts fit together into a larger whole.
- **Good and bad.** Often authors place value judgments on material and organize it into good and bad effects, pros and cons, costs (bad) and benefits (good). This is widespread in college work. Place things into the good/bad framework and your memory will im¬prove.
- **Means and goals.** When you are learning how to do procedures (work in labs, solving problems), you will learn steps that achieve subgoals, which lead to larger goals, which lead to larger goals. Notice and classify this material into means and goals.
- **Concept hierarchies.** Do you remember seeing a biological classification of species and genuses and families and so on? That's a concept hierarchy. Some concepts are general and include many subordinate concepts; and some other concepts are on the same level of generality. When you read material that includes concepts, put them into concept hierarchies and you will improve your memory. Draw charts of concepts.

Study Tip #4 - BASIC MEMORIZING BY THINKING

Outline of basic ways to memorize

1. Link new ideas to both familiar and new ideas.
2. Ask yourself and answer, "Why does this make sense?"
3. Notice similarities and differences.
4. Notice when ideas are new.
5. Notice when new ideas are unexpected.
6. Notice when ideas reach your goals.
7. Memorize typical examples of concepts.
8. Make vivid mental images of concepts..
9. Think of details and fine points.
10. Think of concepts that are more general and more specific.
11. Think how ideas generalize to new examples.
12. Think how to use ideas to reach goals.
13. Think of your personal associations.

The basic idea of this study tip.

When you notice how facts and ideas are related to each other, you build links among them and links build memory. The theme of the Study Tips on memory is that you need to make strong associations among chunks of information in order to learn them. If you have a memory problem, you may not be asso¬ciating ideas in strong ways to one

another. We all forget ideas that stand alone. So think about the ways new inform¬a¬tion relates to other things that you know.

What do "linked with" and "related to" mean? There are far too many relationships to list them all, but here are some: similarity in some way; a kind of difference; novelty; words that can make a visual image; one idea that is a more general concept and the other that is a specific concept subsumed under the other; one idea that is an example of the other; one concept that is a cause of the other; one fact that is a detail of the other's larger whole; and one event that occurred first and other second.

How do you make an association? When you take two facts or ideas and simply notice their relationship in a specific way, you have made an association.

The only shortcut you can use to speed up learning is to think in ways that associate ideas. No thinking, no linking! Don't try to use all of these suggestions at first. Pick one, practice it until you feel comfortable using it, and then try another and another.

1. Take new ideas and link them to both well-learned ideas and other new ideas.

After you read or hear a new idea, search your memory for well-learned ideas that you naturally link it to. Don't limit yourself to associating new ideas only to other new ideas described in a book or by a professor. Search your memory for your own knowledge of links to new information. Think of how the new and the familiar ideas are related. When you can use the familiar idea to predict the new one, you will have the most powerful way to remember.

Also link new ideas to other new ideas. When you read, you will notice many new bits of information. You can improve your memory by thinking how the new ideas are related to each other. Although associating new to new does not produce as strong memory as linking old to new, it is still a good method. You search for patterns among the new items.

2. Ask yourself and answer, "Why does this make sense?"

Take a new fact and deliberately try to answer the question, "Why does this make sense?" Or ask, "Why is this idea true?" Search your mind for what you already know that is consistent with the idea that the new information is true. Research on memory shows that this one of the most powerful learning techniques there is.

For example, suppose you read in a social psychology text that when people feel uncertain about something, they are more likely to seek out others to affiliate with. Then ask yourself why it makes sense that uncertainty increases affiliation; you will find part of the answer in your own memories and part of it in the text. Or suppose you read in a math book that when you make a change on one side of an equation, you must make the same change on the other side. Ask yourself why it makes sense and you'll be led to notice the importance of the equals sign linking the two sides and the need to keep them equal.

What about situations where you know that ideas are wrong. Suppose you are studying an older scientific theory that you know is false. Don't worry about it. Just pretend it might be true and ask, "Why does this theory make sense in terms of the time it was invented?" Then think of answers and they will build memory.

Don't ask yourself, "Why is this idea untrue?" And don't ask, "Why does this idea make no sense at all?" Research on learning shows that people forget ideas more when they search only for why ideas are nonsense. This does not mean that it's bad to do the different activity of evaluating ideas critically.

3. Notice similarities and differences.

When you want to remember a new fact by searching your own knowledge, notice if it reminds you of anything similar. Your simple act of thinking of similar familiar knowledge will boost your memory for the new fact.
Example: My wife once noticed that the name of Faye, a waitress, was the same as one of my aunts. Months later, she saw the waitress, thought of my aunt, and recalled "Faye".

Also take a new idea and notice different related facts or ideas.. For example, learn what the color red is by comparing it to orange and magenta, or understand the concept of social norms better by taking a few seconds to notice how norms differ from values.

Another example: One of my sons said noticing similarities and differences was his main method of learning history. He read, for example, about a certain war and thought how it resembled a later war and differed from it. When studying the American Revolution, he compared it to the French Revolution. His memory grew naturally. Students who think about similarities and differences remember so much that they can often skip the step of memorizing things explicitly.
Tip: Choose two chunks of related information that could be confusing later and think in ways that make the two sets of information distinct.

4. Notice when ideas are new ones.

As you read, think about whether facts are new to you or are already familiar. Research on memory shows that our minds are tuned to novelty; they give extra processing time and make more associations to new information over familiar information. Although in daily life our noticing of what is new comes easily, it is different when reading technical or difficult writing, so we need to look for what is new. Search on purpose for what is new about a book. Your noticing what is new improves your memory because it adds an emotional zing to the idea and it helps you classify it as important. Say to yourself, "That's new!" (Of course, when you see familiar material, don't skip it; read it.)

5. Notice when ideas are unexpected.

Many times information goes beyond being new; it will surprise you or go contrary to your beliefs. Notice it. Say to yourself, "That's a surprise!" That will strengthen your memory for it.

6. Notice when ideas reach your learning goals.

Turn your learning goal into a question. Ask questions. Look for answers. Then when you find one, notice consciously that it is the question's answer. This noticing is important because it brings both question and answer into your mind nearly at the same time. By doing so, you make associations two ways: (1) You associate question to answer, and (2) you associate the feeling of being rewarded to the question-answer link and positively reinforce the memory. Say to yourself, "That's what I'm looking for!"

7. When learning definitions of new concepts, memorize typical examples, too.

When you try to learn new words, you are used to learning the words themselves and their definitions. Add good typical examples and it will improve your memory.

Suppose you needed to memorize the definition of the biological term "mammal". "Mammals are warm-blooded animals that give birth to living young, feed them with milk, and are generally covered with fur or hair." Now as you memorize it, you might pick a cow as an example of a mammal.

8. When learning definitions of new concepts, make vivid mental images.

Associate verbal information about a concept to visual images of examples of the concept. When you think of examples of concepts, use your mental ability to visualize, to see images of the examples. Although pausing in your reading to make mental images takes longer, it is so powerful that it is worth doing. Research shows our brains usually remember images better than words. Put in shape, size, color, and movement.
For example, students of nursing can read about a disease, shut their eyes and mentally see a friend sick, with the disease's symptoms, and lying in a hospital bed on white sheets. You can add auditory imagery (sounds, spoken words). Nursing students could imagine hearing their friend's voices naming the symptoms. Add kinesthetic imagery (feelings of touch, movements of your body). Nurses could imagine touching hot foreheads and feeling the heat of a fever.
You can use kinesthetic images for learning subjects that you might not think of. For example, an Electronics

student studied circuit diagrams by pretending that he was an electron flowing through the wires and parts of the circuit. He imagined feeling the forces on him. A math student improved his understanding of graphs and charts by moving his hands up and down to match the line of the graph. And students of literature, psychology, sociology, and history often imagine feeling people's feelings.

9. Think of details and fine points.

Study a concept very closely and notice its exact features and relate them to the whole thing. There is something very powerful about analyzing things into their parts and then noticing how the parts relate to one another and to the whole thing. Such associations are also powerful memory builders. For example, read an author's argument and sub-divide it into its parts. Read some history and break it into a series of events. Look a picture in a text and break it into parts.

10. Think of more general categories and more specific categories.

As you read about concepts, link them to the larger categories they fit into. For example, when you read about apples, remind yourself they fit into the general concept of fruit. Things that apply to fruit in general also apply to apples. And as you read in sociology about folkways, rituals, and laws, make an effort to place them into the more general category of social norms.

You can also link concepts to more specific concepts. For example, three varieties of apples are MacIntosh, Red Delicious, and Gravenstein. By thinking "up" to general concepts and "down" to specific ones, your memory grows.

11. Think how ideas generalize to new examples.

To generalize means to take a principle or example you already know and think of additional implications or examples that were not used as teaching examples. As you learn principles, first learn the principles and read a few examples. Next deliberately think of new examples not mentioned by the book. The benefit to making generalizations while you study reveals itself later when you might be tested on examples that you never studied but now can recognize because your mind has already played with a range of examples.

12. Think how to use ideas to reach goals.

Here's a powerful way of thinking because it uses desires and wants. As you learn:

- Think about things you want and how the new ideas could help you get what you want (goals first and new ideas second);
- Think how you can use this new information (information first and link to goals second). For example, a mechanics student read about motors and thought about types of auto trouble he could fix by using his knowledge.

13. Think of your personal associations.

Most things we read about will bring personal memories to mind, even unusual memories of things we lived through. As you read, let yourself think about those personal things. Take time to notice and mull over personal associations. Practice thinking of the new idea and your personal association in order to strengthen the memory. Think how your new knowledge lets you see a past event in a new way.

Think of associations in ways that match the mental model of experts in the field being studied.

Although any ways of making associations will help you learn, it is more useful to associate in ways used by the people in the field you are studying. One beneift: You will do better on tests because your instructors will use their mental models as a basis for choosing the wording of questions on exams. If you have built associations based on

their mental models, then when you read their test questions your mind will immediately go to associations leading to useful answers.

For example, scientists think in terms of descriptions, measurement, cause and effect, and making arguments using evidence and reasoning to support scientific theories. You can use those patterns as a way to associate the parts of the new material together. Similarly, other fields have their favorite ways of thinking.

I'm not saying you have to think and memorize all the time in the way that your field of study does because we all use personal associations. But in tests we'd have to translate between the professor's words and our personal associations to retrieve memories, and that process of translating takes extra time and, worse, might block us from recalling things we know.

Study Tip #5 - BASIC MEMORIZING: THREE "LOOK-AWAY" METHODS

Outline of "look-away" methods

Why "look-away" methods work so well.

- Method #1. Easy studying while reading: Read a passage, look away, make a summary, reread, and check your summary.
- Method #2. Serious studying: Teach and test yourself.
- Method #3. Serious studying. Build sets of newly learned facts one-by-one. (Variant of Method #2.)

Why "look-away" methods work so well.

Students are using look-away methods when they read information and then look away from their book or flash card and try to say it to themselves without looking at the book or card. These are effective methods of studying, and many students use them.

The core goal of studying to build memory is to build strong associations among new and old chunks of information. When people must learn many new things, they face dangers of overloading their short-term memories and of later confusing various similar bits of information with each other. Look-away fight both of these dangers while building associations that you can check as you learn. They also give you actual practice recalling your new knowledge and give you definite feedback as to how well you are learning. They save time because you recall information that was just recently entered into your working memory. Since you build associations so quickly and review so quickly, it means you don't have to waste time rereading and relearning forgotten material.

Method #1. While reading do easy studying. Read a passage, look away, make a summary, reread, check the summary and move on.

Use this method when time is limited and you expect you will not read a passage twice. What material would you use it on? Use it on a wide variety of non-fiction in which you learn theories, descriptions, explanations, steps in doing a skill, and arguments for this or that claim. However, it will not work as well as the other two methods on new vocabulary, technical terms, numbers, formulas, and very detailed precise information. It will definitely build more memory for that kind of information than ordinary reading will.

Do this technique right while you are reading, even reading a book for the first time. Do not set the goal of perfection of remembering the main points. Your only goal is try for a summary and to check it and notice what you got and what you missed. Then you read onward even though you haven't summarize perfectly. Later, after you have completely read the material, when you want to study for memory, you will try for more perfection.

- **First**, read a passage. Choose enough to cover several ideas or facts, but not so much that you can't recall a lot of it. Read perhaps a half-page, maybe one, maybe two. If you are working with a dense two-column textbook, make it shorter.

- **Second**, look away. Try to summarize the key points. Summarize the main ideas, key facts, line of argument, or the events that happened. Adjust your summary to the nature of the book or article. Try to talk to yourself in words, and if the passage contained graphics try to visualize them and recall the main points of the visual material.
- **Third**, go back to the beginning of the passage and read it again very rapidly and look for what the key points really are. Don't read too slowly. Neither should you read so fast you can't extract the key points. Search for the key points, both the ones you summarized and the other ones in the book that you missed.
- **Fourth**, as you pick out the key points from the passage, consciously check whether you had put them into your mental summary. Had you remembered each point? If you had remembered a point, let yourself feel good. If you had forgotten it, let yourself feel the emotions that go with making a minor mistake. Do not ignore your emotions. Feel them.
- **Fifth**, move on to the next passage even though you don't remember it perfectly. You move on because you are primarily reading, not studying.

Summarizing helps you in a different way than reading does.

When you summarize ideas in your mind, you **group ideas** together and make associations. That's different than what you do when you do straight reading. When you read in ordinary ways, you encounter the ideas separately, one at a time, and if you keep reading on, they often stay separated. Our minds cannot remember separated ideas as well as ideas that we have associated together. So you can help link ideas together by summarizing them. This summarizing method also uses the natural power of your working memory. Our working memory can remember several new bits of information for a short period of time. After that they fade out. If you choose passages that are short enough and if you review immediately, you will remember many of the ideas even when looking away. That saves time.

Also when you try to summarize right then, you are **recalling information** out of memory, which is exactly what you need to do to build memory. You cause learning both when you put ideas into memory and when you practice pulling the ideas out of memory. Modern brain imaging research shows that the brain emphasizes the left frontal lobe for the input of information and the right frontal lobe for recalling information. It is important to recall information at least once in order to make it accessible later. Of course, many practice attempts work even better for building durable memory. But if you cannot recall something even once when it is recent and fresh in mind, how can you expect to recall it when it has gone cold?
Finally, when you **compare** your mental summary to what's in the book by quickly rereading, you will detect what you did right and did wrong. You help memory by detecting a mistake and correcting it. When you discover you omitted an idea, your natural feeling bad will add an emotional zing which also associates to the new information and increases memory. You will notice what's right and remember it. This works the way it works after an exam and people later discuss it with someone and discover they made a mistake. Once they learn the right answer, they almost never make that mistake again. This reading technique of checking your summary against the contents of the passage will let you learn by making a mistake and correcting it. And when you discover a success, your natural positive feelings will reinforce your learning and increase memory.

Method #2. Serious studying: Teach yourself and test yourself.

Use this method when you find specific facts or ideas that you want to remember. You will need to have a way to see your questions but not see the answer in a book or piece of paper. Use flash cards or cover the answer with your hand while being able to look at the question.

1. Read the fact carefully so that you understand it and it is meaningful to you. Do not try to memorize it until you know it accurately.
2. Then stop reading, think of one or more logical questions to which this idea is an answer, and do the next 5 steps (steps 3, 4, 5, 6, and 7).
3. Look away from your book.
4. On your first try, ask yourself the question as soon as your eyes are off the book.
5. Ask yourself the question.
6. Say the answer to yourself clearly.
7. Check the book and compare what you said to what the real information is.
8. Repeat steps 3, 4, 5, and 6 until you get the fact right several times.

9. On later tries as you have begun to learn the fact, make a time gap between looking at the book and asking your question.
10. Distract yourself for 5 to 10 seconds. After you are quite good, make longer gaps by practicing something else. Even wait overnight before testing yourself again for an even better self-test.

Notice the key steps: You link the information to a question, you distract yourself for a few seconds, you actively recite the answer, and you compare your answer to the right answer. These ingredients are essential.
The purpose for asking a question first is to link your fact to the question and build an association between questions and answers. That makes your practice match what you do in a test in which you will also see questions and recall answers.

The purpose for distracting yourself is to let the idea fade a bit from your memory. You are forced to recall it when memory "is cold" as in real life. That strengthens memory.

The purpose for you actively reciting the answer is give you practice in stating the fact or idea and to let you know in truth whether you learned it. Reciting leaves nothing to chance.

Finally, when you compare what you said to what the book says, you get feedback. You will feel good when you get it right. You will feel bad when you get it wrong and you will now notice what the right answer is with some emotion. Your memory grows.

Method #3. Serious studying: Build sets of newly learned facts one-by-one. Expanding Method #2.

Use this technique when you have a set of chunks of information to learn: a vocabulary list, many facts from a science chapter, lists of principles, etc. You can successfully study many related pieces of information by adding them one-by-one into sets of facts.

- Use it for new words, symbols, facts, formulas.
- Use it when you learn bits of information that you might get confused.
- Besides building and testing the strength of your new associations, this method also helps you to discriminate among related concepts.

Follow these steps.

1. Learn one fact. Use either the method described above or any other method that works. Test yourself.
2. Learn a second fact. Test yourself.
3. Now test yourself on the first fact again. When you've got it, test yourself on the second fact again. Go back and forth between the first and second facts until you understand their differences and know them both.
4. Now learn a third fact and test it.
5. Return to the first two facts and test yourself on them. Check the third fact. Keep working with all three facts until you know them all.
6. Now add a fourth fact. Learn it and integrate it into the set of four facts.
7. Keep adding facts, one at a time, to the growing set of facts. When you reach 10 to 15 facts or come to the end of a logical group, start again with a new set.
8. After learning a set, check your knowledge of it by starting now with the last item in the set and then working forward. Why? The last items in the set get less practice than the early items, so they need special attention to make sure they are learned.
9. This method works well. One psychologist told his teenage son about the method, and the boy immediately used it to study German vocabulary words. He told his father that he learned his words faster than ever before and could remember all of them for the first time.

Do not study many facts separately before you study the first ones again. That has bad results, because you will take a long time going through your list, and the long time leads to forgetting them before you get back to them. You will waste time relearning them.

Note: Many students use sets of flash cards poorly. They look at one flash card, then the next, and the next and so on until they've looked at all of the set. Then they start in again. They find they have to keep looking at the answer side because they never learned the information the first time. By using the method of building up sets, you can learn them thoroughly.

Study Tip #6 - MEMORY TRICKS CAN MAKE SCHOOLWORK EASIER: SIMILARITIES, THE LINK, AND THE KEYWORD METHOD

Outline on Memory Tricks

1. Memory tricks make powerful artificial associations.
2. Use similarities to make associations.
3. The link method.
4. Guidelines to making associations.
5. A brief example of the keyword method.
6. The keyword method step by step.
7. An example of using the keyword method.
8. When to use the keyword method.
9. Why does the Keyword method make associations so easy to remember?

Memory tricks make powerful artificial associations.

You may recall that the essential key to building memories is to make strong associations among the things you want to remember. You avoid learning facts in isolation. Most people study by making fairly natural associations among the parts of the new information and between new information and knowledge they already have. Memory tricks often make artificial associations that are very powerful and easy to recall later.
Which works better—memory tricks or natural associations? It depends whether your goal is short-term or long-term memory. Memory tricks are generally faster and more reliable in the short-term. But if the goal is to study a body of material and remember it for a week or more, then natural study works as well as mnemonic tricks.

Use similarities to make associations.

You can remember any new piece of information if you can associate it to something that you already know. So when you want to remember new information, try to recall something you already know that is similar to it.

You can use something similar about the words or the letters in the words or something in real life. Make yourself stop and think about that relationship. Your purpose is to recall the new item by thinking first of the familiar item that it resembles. You can also use opposites. Here are three examples:

- "Mrs. Harris goes to Paris." The rhyme makes the words similar."
- The capital city of the state of Maine is Augusta." Augusta resembles the month of August, a hot summer month. But that is opposite to cold wintry Maine. An easy association.
- You can spell the word "piece" by thinking "a piece of pie." Two similar spellings.

The Link Method

Students often need to learn lists of items. So use the Link method to make a way to recall a whole series of facts that you might forget if you studied them separately.

The Link method takes items and converts them into mental pictures and links the picture of each item into a common picture with another item. It often uses ridiculous pictures. So when you see a picture of the first item, it is automatically in the same picture as the next item; you recall both.

Here is an example of a list. It uses several study methods from another study tip. Suppose you want to recall (1) the spaced study method, (2) warming up your mind, (3) marking your book, and (4) self-testing.

- **First**, spaced studying: Make a silly picture that reminds you of it. Can you see yourself throw books all around a room? That spaces them.
- **Second**, warming up your mind: Make a picture that reminds you of it, too. How about seeing a match held under a picture of a brain?
- **Third**, now link the spaced books and the warmed-up brain. For example, make your image of throwing books focus on throwing one book at the brain and the lighted match.
- **Fourth**, marking your book: Make a picture of marking your book that's linked to the match and the warmed up brain. That's easy. Picture the warm brain sticking out a hand that holds a pencil and that marks one of the spaced books.
- **Fifth**, self-tests: Link a picture representing a self-test to the marked book. I can make a short mental movie of me seeing a multiple-choice test question and then sneaking an illegal look at my marked book to find the answer. (The fact that cheating is illegal and dangerous makes you remember the image.)

Guidelines to making associations:

- **Substitute** one part of the first object for a part of the second object. To link fertilizer to petroleum, you could imagine a hand holding a gas can and pouring out fertilizer, not gas.
- **Make things out of proportion**. Make little things big, big things little. For example, you can remember that the link method causes memory by imagining a person with a gigantic brain that is wrapped around with chain links.
- **Exaggerate** the numbers involved or the sizes involved. For example, link lemons to vitamin C by imagining a lemon, cut open, with vast seas (C's) inside and letter C's swimming.
- **Put action in your associations**. You can remember that saltwater is a cure for heat exhaustion by picturing yourself pouring a waterfall of salt water over a prone person and seeing the person stand up healthy.
- (*Many of the ideas on links and associations come from **The Memory Book**, by Harry Lorayne and Jerry Lucas. Paperback. Good.)

The Keyword Method

The keyword method is an excellent way to memorize a new word and its defi¬nition. You make a mental image of each one and then blending the two images into one picture. Here is a quick overview. For an example, suppose you use it to memorize the French word "le chien" which means a dog. First, you notice that the sound of "chien" is like a shin, the front and bottom part of our legs. Next, make a picture of your "shin" and put a dog biting your leg in the same picture. Presto! New word and definition are linked. Later if you want to recall either one, you think of your image and figure out what you want.

This is a very powerful technique. Researchers recommend it. Even people with bad memories can remember things with it.

I recommend that after you have figured out how to use the method you practice using it on 3 words and their definitions, words that you already know. If you do that, you will create a specific memory of how to do it and will be more likely to do it later.

The Keyword Method Step by Step

- Understand what the new word means. Do it clearly and fully because it is important. Use good ways of understanding, such as making visual images of the meaning, talking to yourself about what it means, and thinking how it feels.
- Take the new word and choose a keyword that **rhymes** with it. Choose one that you can think of naturally. It is often enough to have it rhyme only partly with the new word. For example, you might take "melancholy" (which means depressed) and use "melon" as a keyword. Always choose rhymes, bad puns, similar sounds.
- Make a vivid mental image of the keyword. (Don't make a mental image of the original word.) Here's how to make the image vivid: Put in color, shape, one or two details, sounds, physical feelings, movement, or any combination of the above.
- Now turn to the definition and also make a vivid mental image of it.

- Now make an **interactive image** out of the two images. The purpose is to make such an integrated image that when you think of one image you see the other. Here's how to make an interactive image: Put the two images in the same unified picture. Make them relate to each other. For example, the things in one image could touch or hit the other. One image could be put inside the second, one on top of the other, or one a part of the other.
- Now you test if your images will work. Start with the original word again. Practice thinking of the keyword next, then the keyword's image, then the interactive image, then picking out the image of the definition and translating the picture of the definition into the words of the definition. Continue until it's easy. At this stage you may notice problems. Improve your images if you need to.
- Now make a backward test. Start with the definition. Practice thinking from the definition in words through the images back to the original word. Practice until it is easy.

An Example of Using the Keyword Method

Suppose you need to learn that "der Steg" (a German word) means a footpath.

- Study both the German and English until you clearly understand the meaning of the words. Get the pronunciation correct. Don't skip this step.
- Choose a keyword. For example, "steak" sounds close enough to "Steg".
- Make a picture in your mind of some nice, red, raw, juicy, dinner steaks.
- Make a picture of a footpath. You could think of one shaded by branches with two children walking along it.
- Fuse the two images into one. For example, imagine that the children throw several steaks onto the dusty path.
- Do forward practice. "Der Steg", the word "steak", picture of steak, picture of path, picture of children throwing steaks onto path.
- Do backward practice. The word "footpath", picture of path, picture of children throwing steaks onto path, focus on steak, word "steak", word "Steg".

When to Use the Keyword Method

When you need to learn new vocabulary words that you would find hard to remember naturally, think of the keyword method. It is good for learning foreign vocabulary and for scientific and technical words. Reminder: Even new words learned by the keyword method will fade over time unless they are practiced.

Why does the Keyword method make associations so easy to remember?

If you have ever seen or read about a memory expert learning a large mass of new material quickly and accurately, you are aware of the power of mnemonic methods. They make an easy trail for the user's mind to follow both when learning and later when recalling so that there are no random meaningless jumps to make. In contrast, ordinary learning often leaves a person puzzled later as to what things to think of in order to use an association that will retrieve a memory.

Notice that the keyword method's first learning step involves taking the new word and finding a pun, a sound-alike word. You take the word and think of an association that the new word makes to you. That step also comes first in one's later memory search. In the earlier example of shin-"le chien", the word "le chien" reminded me personally of a shin and I chose it. So in retrieval I always know when I see "le chien" to check memory for a something easy and concrete—the sound-alike word. The association is not an arbitrary association between one meaningless word to a forgotten one, but between a word which is right there and a sound which is right there. All I have to recall is which possible sound I chose and to recall an image of the sound-alike word—my shin in this example.

The second learning step is to take the definition's meaning and make its picture. That step always comes second, so my mind can create the image. Since "le chien" means a dog, I made a picture of a dog. Then I went to the third learning step to put the picture of the shin and the dog in the same image.

When I recall the word, I normally won't recall the step of making the definition's picture because as soon as I go to the image of my shin I will automatically see the other parts of the image integrating the dog and the shin by the dog biting my shin.

When we recall information using a mnemonic method, our minds follow a trail that we created earlier with natural associations until we come to an integrated image containing two or more parts that are tied, attached and bound together.

Note that the keyword method uses visual links, but you could use verbal or kinesthetic methods, too. A verbal integrated unit might be a sentence or a silly pair of names. A kinesthetic image might be a sense of touching something linked with a visual image of what touches it.

In summary, the keyword method works well because it takes words and odd facts that by themselves require brute force repetition to learn and finds a way to make a series of natural associations step-by-step to create an integrated visual image. Later when you recall the new word, you jump from the word to its definition to its image and to the integrated image. Notice that if you can study any other new material and also find natural step-by-step ways to lead to integrated images or sentences or other units you can also create quick learning of complex information or unusual words. Think about it!

Study Tip #7 - TEACHING YOURSELF COGNITIVE SKILLS

What are cognitive skills?

Cognitive skills resemble physical skills. You may know that a physical skill means an ability to do a physical procedure accurately and fast. (Examples: playing a sport or musical instrument, using a tool, driving a car, running.). To have a cognitive skill means having ability to do a procedure that involves perceiving the meaning of situations, thinking about them and responding effectively. (Examples: playing chess, writing an essay, solving math problems, reading and using tact in difficult social situations.) Probably all skills have both physical and cognitive aspects to them, but the emphasis among skills varies.

Starting to learn: the cognitive stage.

You will start by getting information about what to do in ordinary ways: reading a page of directions, watching someone do the skill while explaining what they are doing, reading a worked-out example of solving a problem, or learning by trial and error. This stage may take a few minutes or a few hours or many years, depending on the complexity of the steps you are learning.

- Example: to learn a math procedure, you may read the textbook and listen to your instructor. You may study a worked-out example or just jump in and try the problem. As you try problems, you will go slowly, refer back to the directions and the worked examples, and get feedback from the textbook's right answers.
- Example: To learn how to write essays that make an argument, you may read directions and then study a couple of essays that are models of good arguments. Then you may write an essay yourself and look back at the directions and the models and compare your essay to them.

Continuing to learn: the associative stage.

You will begin to detect mistakes and eliminate them. You will begin to associate the various steps to each other; you will change from doing steps one-by-one and begin to group them into chunks of several steps that you can do in one unit. You will begin to remember the steps and to learn shortcuts. Your speed and accuracy will improve. This stage may also take a few minutes or a few hours.

Continuing to learn: the autonomous stage.

As you continue to practice the skill, you will continue to improve your speed and accuracy. You will be able to act more automatically. You will be able to do the skilled tasks with less concentration. This stage may go on for months and years.

Long learning time is needed for skills.

People need much longer to develop skills than to learn ordinary factual knowledge. One psychologist noted that students learning one skill needed to practice about 40 times with each new step. It takes people additional time to integrate a series of steps into a smooth procedure. In contrast, in ideal circumstances people can learn a new chunk of knowledge in less than 10 seconds. That means you should plan to do a lot of practice when learning skills.

Teach yourself the goals, situations and actions for each step of a cognitive skill.

First, each step will have its own **goal or subgoal** that helps signals what to do. For example, when you learned to add several columns of numbers, you learned a series of goals: to add first the right column, then the next left column, then the next left, and so on. You also learned goals for handling subtotals that add up to more than 10 and to carry 1 or 2 or 3 or more to the next left column.
Second, you must teach yourself to recognize **situations** that also govern what to do. Consider the different situations when adding numbers: having just added the first number in the rightmost column, having added a middle number, being finished with a column, having written down one-digit for the subtotal, having a number to carry versus not having a number to carry, having a second column to add, and so on. Consider a basketball game: part of a player's skill is to look at the changing patterns of what the other players are doing as situations to recognize. Learn situations as part of your skill learning.
Finally, learn what **action** to take for each combination of situations and goals. Situation-goal-action.
As you read directions for doing a task or as you study a worked-out example, break down each step into its three elements: the situation, the goal, and the action to take. If you are listening to a teacher who just says, "Do this, do that, do that," you will learn better if you ask the teacher to point out the situations and goals that govern each step.

Study worked-out examples.

Don't just read directions and ignore the examples. Worked-out examples are powerful. Research demonstrates that people who study worked-out examples in math and other subjects can use them as models for their own attempts to do the skill. When you find that a type of problem or skill is complex and that you confuse it with other skills, it is helpful to memorize a worked-out example. Later, when you encounter a similar problem, you can use the memorized example to reteach yourself what to do.

Get feedback.

When you practice a skill, it is vital to know how well you are doing. Get answers for problems you solve and get expert reactions to your creative work and get a teacher's evaluation of lab work and use of tools. Why? By getting feedback, you will correct mistakes before your practice hardens them into bad habits.

Summarize.

When you finish a task successfully, pause a minute, make a mental summary of the steps you followed. Ignore the false starts and mistakes you made. Just summarize the right series of steps. Your purpose is to remember the general pattern of steps you went through so that you can go faster the next time you encounter that task.

Congratulate yourself and feel good for using the technique that led to success.

In addition, when you finish a task, you can also boost your memory by reinforcing yourself. Give yourself praise, tell yourself you did a good job, and call up a positive feeling.

What should you reinforce yourself for? Praise yourself for doing the procedure well. Don't think just about success. Think about how you used a good technique to bring success. Think cause and effect.

Why? What is the purpose? Why not just stay neutral in your feelings and go on to the next task? The reason is that one way our minds learn is by repeating actions that lead to pleasure and by avoiding actions that lead to pain. It seems probable that when we feel positive emotion after doing a skill and getting success, our brains create "long-term potentiation" between the neurons involved, and that increases the permanence of the learning.

Space out your practice.

Research on learning skills has demonstrated that students who spread out their practice sessions, instead of concentrating them into just a few sessions, do not need as much time to build up their skill to good levels of speed and accuracy. One researcher used sessions of 30 minutes twice a day over four days. People training dyslexic readers use 10 to 15 minute sessions daily for periods of months and find it works. This fact means that, unlike learning ordinary knowledge, you cannot put off learning skills until a cram session at the end of the term just before final exams.

Trouble-shoot mistakes by changing chunk size.

Some of our mistakes and slow performance are influenced because we try to learn too many skill steps at once. If so, learn and practice less at a time.

- Break down a group of steps into smaller units. Analyze and practice just one step at a time.
- When even one step with its linkage of situation-goal-action is too much to wrap your mind around at once, break it apart and study first to recognize the situation, then to identify the goal of that step, and finally to drill yourself to see that situation-goal pair and respond with the action.
- When even that is too much, break each of those units apart and study them separately.
- Practice very slowly.
- When learned habitual mistakes occur, practice slowly and away from competition and pressure. Use much extra practice to break bad habits.
- On the other hand, some of our mistakes and slowness come because we have not grouped together the steps of a new skill into larger units.
- Practice doing several steps together quickly.
- Get the feel of flowing with several steps.

Different subjects have different learning techniques.

Various games, sports, subjects and professions have developed individual learning methods. Pay attention to them. Use them. They can add to the general techniques that were described in this study tip.

Study Tip #8 - TEACH YOURSELF PHYSICAL SKILLS

Introduction:

At some point you may need to learn to do physical skills well. For example, you may need to play a sport like tennis, to play a musical instrument, to keyboard, to weld metals or hammer nails or clean teeth or drive cars. You can use the following techniques to learn faster. As in all learning you will learn to do things accurately, associate information and goals and actions together, and make the associations very firm.

"MIST-STARS"--the main idea.

Develop Mental Images from your Self and Teachers about STimuli and your right Actions that lead to Results that match the Standards.

Some Examples of Learning Physical Skills

- From time to time I have tried to learn to play tunes on the piano. Once I tried "Home on the Range." I have heard it sung before and have a **mental image** of how it should sound, the **standard**. I could see the notes on the page of sheet music; they are some of the **stimuli** I see. As I strike the keys with my fingers I am making **actions** that produce the **results** of sounds in a poor jerky rhythm with mistakes. I can compare my poor tune (the results) to the real music (the standard) and can plan to correct it and improve. When I eventually learn to play the tune, I will have an inner **mental image**, a "memory in my muscles."
- I taught my children to drive cars with stick shifts. It is hard to do. When drivers shift, they do a sequence of actions that is complex and closely timed. Their right hand moves the gear shift and their feet press the clutch and accelerator. They must feel the stimuli of their feet's position and hear the stimulus of the engine's speed. As they act, they have to notice the result of the gearshift's position and compare to what it should be, the standard. To learn to shift smoothly, they must notice the result of jerky shifts and compare it to a standard of smoothness. My kids did not always notice jerkiness, and I had to teach them to feel smooth versus jerky shifting. Once they learned to drive, their mental images came from personal memories of good driving.

Start by Watching a Model

- Watch someone good at the skill do it and create a mental movie image. Don't expect to get a perfect mental movie, because skilled people move quickly and do many actions. All this complexity is hard for beginners to see and understand clearly. Even so, when you see models acting naturally, you learn a lot because you see their rhythms and action patterns.
- Ask the skilled person to do the action slowly, to break it into little bits.
- Ask the model to explain three things for each step: the current goal, the situation as they see or hear or feel it, and exactly what action to take.
- Ask the model to carefully show the fine points of the actions, to describe how to identify results that match the standard.
- Copy the model. Depending on the actions, you may break them down into natural short chunks. When the skill permits it, try to move at the same time the model does. You will learn faster acting at the same time than if you watch first and copy after, because you won't forget as much.
- Form vivid memories of the goals, stimuli (situations), actions, results, and standards. You may take notes, study written manuals, examine pictures and view videotapes and anything else useful.
- A common error that both teachers and students make is to focus only on the actions. The reason you should also learn about the goal and situation pairs is to know when to act. The reason you should learn about goals, results and standards is to get feedback so you can improve.

Set your goal before you practice.

Think before you act. Think about your mental image of the teacher first. Try to copy it. The purpose is to give your mind a model to guide your actions.

Choose a part of the skill that you think you can do. Don't try things that are too fast, too long, or too complicated at first. If you try too much, you will make too many mistakes. Plan to do it slowly, only a short part of it, and in a simplified way. Notice that this simplicity means that you set a sub-goal of learning a "beginner's standard." Judge yourself by your own phase of learning.

As you practice, think of your goal as wanting to produce results that match the standard, but also accepting a beginner's standard until your skill improves.

Notice feedback. Compare your results to the standard.

After each time you practice your action, pause. Be still and go inwards. Notice how well your results matched the standards. This is the time when you get the information you need to make corrections. Use your eyes, ears, sense of touch, and your mind to find the result you produced. You should decide what ways your result matched the standard and what ways it differed. Use your mental image of the teacher in the early phases to compare to.

Build mental images. Remember success.

Consciously notice the inner feeling of your own good actions and make new mental images, new memories, of them. You will use these internal images to guide your future actions. Let yourself gradually stop using images of seeing your teacher's actions. You will now have an inner feel for what's right and wrong and can correct errors before they start.

Practice to build up your speed and accuracy.

Practice, practice, practice. The more you practice, the more you will learn. This is very important. The ancient law of exercise. You can't practice too much.

- **Do slow practice** sometimes to build up accuracy. It is important to practice slowly even when you are good.
- **Do fast practice** sometimes to build up speed, even if you make mistakes. Fast practice will help you pick up the rhythm, the feel, the pace of normal exercise. Accept normal mistakes.
- **Do mental practice** after you have memorized mental images of correct actions. Research has proven that people can improve their skills by mental practice, as long as they avoid practicing doing mistakes.
- **Caution:** Always notice the feedback to your actions. Otherwise, you can accidentally practice mistakes to the point where they become habits.
- **Make creative visualization of success.** It is helpful to visualize success and to imagine self-confidence in your skill.

How to Correct Mistakes.

Often you will develop habitual mistakes in your actions. This can happen even when you "know better." You will intend to change your behavior but will repeatedly fall right into the mistake again. Here are three cures.

- Do slow practice. Slow your practice rate down to a speed that permits you to concentrate fully on what you do in each situation. Practice the correct action and note feedback again and again. As you get better, build up speed.
- Do practice of sub-skills separately. Practice the problematic skill apart from the other skills. For example, practice one musical chord, one move in football, one word in typing.
- Practice inhibiting the wrong action. Think of the stimulus that triggers your action, start to do the mistake, stop, say "No", and switch to the correct action. Next merely imagine doing the mistake and saying "No" and switching. Next shorten the cycle still further. Build an inhibition against using the wrong behavior.
- Warning: If you build an inhibition, your brain may always need to take an extra half-second to think of the wrong action, stop it, and switch to the correct action. In sports and music you must not waste that time. So always add slow practice and sub-skill practice of the right action.

Avoid Self-Talk. Concentrate. Shut your mental mouth.

During the very early phases of learning a physical skill, you may want to talk to yourself as a way to remind yourself of what to do next. That's okay in the beginning. But as soon as you get past the beginning, you should stop talking to yourself.

Why? People who practice physical skills need to put their full attention on the stimuli and their actions and the feedback. Research on skills shows that people who concentrate without talking learn faster and make fewer mistakes. But people who constantly tell themselves what to do and who criticize themselves are stealing mental space in their working memory and are taking time that they need to operate their skill with. They make more mistakes. There are two times it is useful to be quiet mentally: (1) When you watch the stimuli that signal an action (as a tennis player watches the ball coming), and (2) after you have acted and want to notice the results and plan corrections.

Remember MIST-STARS. Mental Images from your Self and Teachers about STimuli and your right Actions that lead to Results that match the Standards. People who practice physical skills need to put their full attention on the

stimuli and their actions and the feedback. Research on skills shows that people who concentrate without talking learn faster and make fewer mistakes.

Study Tip #9 - TAKING USEFUL CLASS NOTES

Why Should You Take Notes in Class?

How would you like to study using a technique that is one of the top predictors of students' grades on tests? That technique is taking notes. Recent research has shown that the higher the quality of students' notes, the higher their grades, all other things being equal.

If you listen to a lecture and decide not to take notes on it, you must trust in your memory to recall it. When you prepare for a test, you will have nothing written down to review with. Can most people remember enough facts from lectures to pass tests several weeks later? "No!" say psychologists who have compared note-takers to listeners.

Why not? Most people can keep information in their working memories for only 15 to 20 seconds unless they recite it or deliberately memorize it by making associations to it. And during lectures people don't have the time to recite, make associations and memorize. Moreover, during a lecture with much new material your mind forgets because the many bits of new material interfere with each other's associations and confuse you. That means you listen and you understand at that time, but when the lecturer moves on to new topics, you forget. And if that forgetting during a lecture isn't bad enough, more forgetting happens in the hours and days after the lecture as normal interference and fading weaken the new memories. Only 10% of the material may last. It's often better if people take notes and review them later: they can recall about 80% of a lecture.

When Should You NOT Take Notes?

There are times when your concentration on taking notes can interfere with your need to understand new and complicated material. Note-taking and listening while thinking about new ideas give your mind two fairly complex tasks to do and they interfere with each other. When a lecturer gets into complicated material, the interence gets worse.

When you need to understand, pause from taking notes and listen and think. Then once the difficult complex part passes, resume note-taking. As soon as possible jot down things you might forget later.

What Material Is It Useful to Take Notes On?

- Use the instructor's goals as a guide. You should set as your top goal to figure out what your teacher wants the students to learn. When you know these goals, you can listen for information that helps you reach those goals. Take notes on anything that will help you learn what the teacher wants the students to learn.
- Write down the questions teachers ask as well as their answers. Why? First, the questions often reveal the teacher's goals and objectives. Second, teachers will ask questions on tests, and if you have written the questions in your notes, you can review by asking yourself those questions and reciting the answers. You will associate stimulus to response. You will use the questions as stimuli to build associations.
- Write down the titles of lists. Why? The title helps you organize the material and becomes a stimulus to build associations.
- Write down general ideas: concepts, hypotheses, summaries, formulas, cause-and-effect statements, main ideas. Why? You will need these general ideas later to help you interpret concrete facts. They're often easy to understand but also easy to forget.
- Take notes on examples. They illustrate the meaning of general principles and concepts. You can be brief. Use just enough words to remind you of the example. Why? Examples are useful when you find general ideas unclear, because you can get clarity by studying examples.
- Write down most new words, concepts, technical terms, and phrases with technical meanings. Why? New words are relatively hard to learn, easy to confuse with others, and fast to fade from working memory. Yet you will need them constantly. So write them down.
- Copy down diagrams, charts, and tables that summarize information.

- When a teacher explains chains of reasoning (math proofs, scientific reasons, evidence for ideas, etc.), you should take notes on each step.

What Style of Note-Taking Works Well?

- The Academic Learning Skills Department at Lane Community College recommends that students use the "Cornell system." You draw a vertical line down the page about two and one-half inches in from the left margin. You write your notes in the space on the right. You save the space on the left to use when you review. In it you later write the key words, study questions, and important phrases. It becomes (1) an outline for review and (2) a set of cues for you to use when you practice reciting the material without looking.
- Write numbers and letters to separate the major points. But do not try to make a formal outline of a lecture. The reasons are that you will not usually have enough time and most teachers do not speak from formal outlines.
- Use separate lines for separate ideas. It adds clarity when you review. Let yourself waste paper.
- Draw boxes and circles around related ideas. Underline key words. Draw arrows to connect related information. These lines signal things to associate together. Use two or more pens with different colored ink if it adds clarity. Distinct colors help you distinguish differences among concepts.
- Try to be neat.

How Can You Deal With a Fast-Talker?

Occasionally, you will take notes from a teacher who talks so fast that you cannot write fast enough to keep up with the information. Fortu¬nately, this is rare. Most teachers help students take notes. They restate each point several ways. They add examples and they apply points to sev¬eral situations. They explain things and conclude with sum¬maries. They use extra words and that gives you time to take notes.
However, when a teacher does talk too fast, you must accept the unpleasant fact that you can only get the high points and that you will miss things. Here are some options as to what to do:

- Write faster. Omit unneeded words. (the, a, and, etc.,). Abbreviate words (w/o for without, acctg for accounting, etc.). Write in phrases, not sentences.
- Stop trying to spell right.
- Stop trying to think about the material. Just listen and write. Exception: Sometimes a teacher would prefer that you listen to an explanation of a complicated idea so that you understand it. Then you can stop writing.
- Make your attention switch back and forth rapidly between your writing and listening to the teacher. You hear an idea, you notice yourself start writing a word or phrase, you put your handwriting on automatic, you switch to listening again while writing, you switch to noticing your writing, and so on. You should try to develop this skill.
- If you fall behind, then leave a gap of several lines in your notes, skip what you missed, and start in again where the teacher is. After class ask another student for what you missed.
- If you cannot both listen and write, and if you think understanding is more helpful than writing notes now, simply stop writing and concentrate on listening and understanding. It is particularly safe to listen when the ideas are general and there is little new vocabulary. But when there is new vocabulary and specific facts, then struggle to write mindlessly.
- Tell the teacher about the problem and ask for repetition or for a slower talking speed.
- Right after class is over when you know you've missed things, try to go over your notes immediately and fill in what you can remember of the missing spots. Add details and examples that you skipped during class. Do not delay doing this. The longer you wait, the more your memory will fade. But if you act fast, you can remember a lot.
- You may suspect you write too slowly and take too many notes. You can find out by looking at other students' notes.

How Can You Use Notes to Review?

- Do review them. If you take notes and don't review them, you will forget as much as a person who just listened. Use distributed study; do multiple reviews with time intervals between reviews.
- Review soon after the lecture. You will remember more right away than if you wait till later and your memory has gone cold. This early review will repeat associations you made during the lecture and add new ones.

When you review two or three times more, each review makes the associations firmer so that test questions about the new knowledge will trigger strong associations and let you recall it.

- Review both your lecture notes and similar textbook passages at the same time. It will build associations that make memory easier.
- If you use the Cornell system, write key words and questions in the left margin. Then cover the right side, look at the material on the left, and try to recite the full material. Then you should check your memory by looking at the material on the right. If you missed some points, cover it up and try again.
- If it's possible, try to recite aloud. If not, try to "talk to yourself" silently. Do not mumble in your head. Do not make vague pictures of the answer. Vagueness in review causes poor memory. Since you know you will be tested with words, you need to use clear precise words while you review.
- Here is a psychological trick: Look to the left, make a picture of a good friend, and recite your answer to that person. It works.
- Think about the meaning of the material. Compare where it is similar to textbook material or different.
- Hunt for how the material is organized.
- Study the examples until you can tell how the principles are used in them.
- Will a later lecture's content build on a prior lecture's content? If it will, review your notes before that class. Why? You will put that information into your working memory and activate the part of your brain that knows that subject. The result will be that you will understand the coming lecture better than if you listened to it cold. Psychologists have proved it.

Tape Recording and Recopying.

- Should you use a tape-recorder? Not usually necessary, but some people find it helpful. Some people play tapes while driving. If you tape classes, you will still find lecture notes useful. With a set of notes you can reread the main ideas of an entire lecture in 3 to 5 minutes. Without notes, you need to listen an hour to get the same information.
- Will it help if you recopy or retype your notes? It can help when you use a computer and rearrange notes to highlight concepts, examples, principles. On the other hand, recopying notes does take a lot of time, and you may choose to study your original notes. Try to take reasonably neat notes the first time.

Study Tip #10 - HOW TO CREATE A POSITIVE ATTITUDE AND STOP PROCRASTINATING

Outline

- Discouragement is a normal problem.
- Think about your deep positive goals.
- Think of specific purposes.
- Get support from another person.
- Think why you believe you can succeed.
- Think of bad results of not working.
- Think that time is short.
- Think that you freely chose to work.

1. Discouragement is a normal problem.

You may have noticed that when you feel discouraged about a class or a hard assignment, you tend to give up working. It is not unusual and it's a problem you can fight. Several normal things in most students' lives make them feel discouraged every so often. For example, as school goes on, people forget their purposes, they doubt their ability, and they get deeply tired. And if you can fight it and keep working, the discouragement won't harm you. It's at times like this that you need to know how to find your natural motivation so that you feel willing to try again. There are several honest ways to motivate yourself.

Where do the following suggestions come from? Just as many of the suggestions in the Study Tip series are examples of the general principle that learning comes from making firm associations, so, too, does discouragement

come from well-learned negative associations. And positive attitudes can come out if you start retrieving knowledge and goals from memory that you associate with positive feeling.

2. Think about your deep positive goals.

In general, people who have a purpose for doing a task feel motivated to do it. People who lack a purpose, but do a task only because they have to do it, feel bored and resentful.

- Call to mind your deep positive goals. Think why you value them. Now think how going to school helps you reach them. Next think how taking your courses helps attain your goals. Next think the awful thought of how you could hurt your deep goals if you give in to your negative feelings and skip studying. Finally, use this realization as your emotional energy to want to study. Decide to study.
- Think of your values. Think of what you stand for, of what limits you will not step over. Think of your ideals and your standards of excellence. With these values in mind, now think of what will happen if you give in to your negative feelings and skip studying. Will it violate your values? If so, use this understanding as the basis for emotional energy to decide to study.
- Think about the rewards you will notice after you do your tasks. Visualize them and imagine feeling them. It will help. For example, can you remember the satisfying feelings of accomplishment that you feel after you create something? Now look ahead to finishing that English paper, doing that math and learning it, and knowing that history. Imagine feeling satisfying feelings of accomplishment. Use them to motivate you. This suggestion is based on the power of positive reinforcement to motivate people.

3. Think of specific purposes that you accomplish by doing this homework.

Research shows that working to attain specific purposes and goals has great power to focus and motivate us. If you don't set a purpose while studying to find and learn something, you will drift into working for substitute purposes. It is emotionally dangerous just to work to get a task done without caring about it. (See some useful purposes discussed in Study Tips #1, #3 and #6.)

- When you get a specific assignment, try to feel curious about what the information will say. Be specific to yourself. Curiosity is powerful and it is the most natural motive to arouse when you study.
- Let yourself want to master a task. When you feel the mastery motive, you will want to answer what's important in each assignment. Every book, chapter, and section will differ. Figure out important questions; ask them to yourself; set the goal to hunt the answers. Use your instructor's teaching goals as clues.

4. Get support from another person.

When we hear other people tell us why it really matters to do something, we believe their reasons more than when we tell ourselves. Ask someone who knows, "Tell me why doing this homework and going to class is all worthwhile." Listen to what they say. So find someone who knows, tell them that you will inevitably feel blue and irritated at school from time to time, and that you want them to encourage you. In fact, tell them some things to say to you. They can often have surprising power to help you motivate yourself to work again. This suggestion is based on sociologists' and psychologists' research on the power of other people's opinions on people.

5. Think why you believe you can succeed.

People who believe that they can succeed are likely to try things. People who expect to fail a task want to avoid working on it. That means that when you believe that you can succeed in understanding, remembering, and solving problems, you will be willing to work. This suggestion is based on an area of research called "perceived self-efficacy". It is very powerful.

How can you get support for your self-confidence?

- You should actively and repeatedly think over the following kinds of thoughts. You cannot just think once and quit.

- Actively notice your successes. Later recall them. Connect your past successes to a belief that you can now learn something new.
- Learn how to learn. When you know you can learn, then you can know something is hard and that you can learn it using good study methods and taking time. Then when your dark doubts sing their dirty songs in your head, you can sing back, "I can learn."
- Find out if other people have learned the same material before. Find out if anyone with your general abilities and prior knowledge has been able to learn it. Ask your teacher and other students. If others have succeeded, you know you can, too.
- Find someone who believes in you and who will tell you so. Say, "I need to be told I'm smart enough to do this."
- Set reasonable standards to evaluate yourself with. Stop setting perfectionistic standards. People sometimes expect that they should be able to read material just once and then recall it at will. No! Memory requires deliberate study; skills require much practice. So keep in mind the facts about learning and study. Allow yourself to make normal mistakes. Then you will believe you can succeed with study and time.
- Set daily attainable short-term goals. Although it seems so simple, setting limited daily goals is a major technique to help motivate athletes to keep practicing. It also works for studying knowledge and cognitive skills.

6. Think about all the bad results that will happen if you don't work.

When people sit down and think through the good and bad results that they can cause by making their decisions, they avoid bad decisions much more effectively.

- As you think about the consequences of putting off your work, think of the past when you procrastinated. Later, did you have to do the work in a hurry? If so, did you dislike the pressure? Did you notice that your first decision to delay led to the bad habit of delaying and your problem got greater? If in the past you created bad situations, you will naturally want to avoid that past pain. So use the memory of past pain to decide to study.
- Also think about the future. If you follow your negative feelings and avoid your work once, what is likely to happen? Are you likely to put it off again? If you avoid it repeatedly, what may happen? Do you like those results or do you want to avoid them? Know that your decision now creates your future. You will live with it. Create only what you want!

7. Think that time is short.

When people think that time is short and that they might run out of time, they feel motivated to work. However, when they think they have plenty of time, they feel relaxed and unwilling to work. So if you deliberately want to raise your motivation, then think of these things:

- Think about how short the time is before your assignment is due. Be specific.
- Think about how many other activities are competing for your time. Be specific. Include hours of eating and sleeping. Realize that you have even less time for truly working than it looks like.
- Think about unpredictable events that might steal your time. They might stop you from getting your work done.
- Think about the blocks of time that you have available soon that you can work in.
- Then let yourself act!

8. Remind yourself that you freely chose to take college courses. Avoid rebellion.

People who have freely chosen to do something usually feel they like it. People who were forced into doing something dislike it. They dislike having their freedom to choose taken away from them. Social psychologists call it "reactance" when we are in rebellion against something taking away our freedom; it is a powerful motive and can damage our attitudes toward studying.

- This principle affects students because their teachers give them assignments and require them to do things. Gradually, they forget that they chose to take the course and feel resentful. Eventually, they rebel against working.
- So if you begin to hate the authority of your teachers, you can cure it by remembering your own choices and goals. Remind yourself that you personally chose to take your courses and that you freely want to do your work.
- Don't keep thinking, "I was forced into this" because it leads you to resent your work and to run away from it.

Study Tip #11 - MOTIVATING SOMEONE TO KEEP TRYING

Outline of ways to encourage

- How to spot discouragement
- Talk about the person's abilities.
- Talk about backup help.
- Talk about effort and study techniques.
- Talk about goals, subgoals.
- Talk about the high value of learning.
- Talk about things that can change.
- When not to encourage a person.

To the reader:

Give this Study Tip to a friend, parent or relative. Or use it yourself! (Also read Study Tip #10 on getting to a positive attitude.)

Students feel deeply discouraged sometimes by long hours of study, difficult courses, and other problems. Research shows that many students do feel discouraged and tempted to give up. It also shows that students often respond to encouragement. Yet sadly often their friends don't try to encourage them.

This Study Tip will teach you some proven ways to encourage others (and yourself!) to keep working. I suggest you do these things:

- Watch your friend's degree of willingness to go to class and do schoolwork. You may see your friend get discouraged.
- Then remember that your goal is to help your student friend to succeed.
- And encourage your friend to persist.
- The information below tells how.

1. How to spot discouragement in a student:

When you hear a student saying that courses are "too hard" and that he or she lacks the ability to succeed, you're hearing discouragement. Also, you will see discouraged students looking tired, depressed, and apathetic--especially when they talk about courses that give them trouble. You can see more subtle signs, too. Discouraged students may look cheerful and busy, but they skip classes and put off doing their schoolwork.
Finally, if you know what situations put stress on students, you can predict discouragement before you see it. Here are some examples:

- Stress occurs at the start of a term (things are new and look hard).
- Stress occurs before and after tests (students worry about doing poorly).
- Stress occurs during big projects (again students worry).
- Stress occurs during day-to-day dull periods (students feel bored, put off doing their work, and feel guilty).
- These clues will help you spot discouragement in your friend. And, of course, because you know your friend, you will know other signs of discouragement.

2. Encourage by talking about the person's abilities.

You probably know that discouraged students usually think they do not have enough ability to succeed in the task that bothers them. You can help discouraged students by reminding them of what their true level of ability is.

- Start a discussion about the past hard projects that your friend has succeeded in doing. Help your friend fully remember how much ability he or she had then.
- Help your friend remember that at least he or she has the ability to learn. The ability to learn is important in school because often students cannot at first master knowledge and skills, but they can learn by persisting. If the student does not know how to study effectively, teach the student good study methods.
- Tell your friend that you, personally, believe he or she has enough ability. Say it often. Say it in many ways. People feed on their friends' belief in them. They love to hear someone say they can succeed. (But never lie!)
- If you are talking to your friend before a big test or project, help your friend break the big task down into its little parts. Help your friend see, one by one, that he or she can do the little parts. That will lessen insecurity.
- If you are talking to your friend after a failure, help your friend understand all the other causes besides "low ability" that helped cause the failure. Talk about lack of time, difficult external pressures, not enough effort, and not being taught the right techniques. Talk about true excuses! It's okay! It's honest!

3. Encourage by talking about backup help.

Many teachers provide backup help for students. They often wait to be asked by students who need it. So suggest that your friend find out if the teacher can provide such backup as extra books, tapes, tutors, more time, makeup tests, or something else.

4. Encourage by talking about effort and study techniques.

Remind your discouraged friend that besides their ability, two other factors affect their success: the amount of effort they put out and the techniques they use.

About effort: Many poor students do not realize how hard and long the good students study. If they would study longer, they would succeed better. Encourage your friend to realize that studying longer will lead to more success.

About techniques: Many poor students use inefficient study methods. It has been proven that students who switch to better techniques learn more, learn it faster, and remember it longer. Encourage your friend to realize that he or she can find better methods. Buy a book on studying, take a course on effective learning, get study tips at your college.

5. Encourage by talking about goals.

Students get discouraged when they believe that they cannot reach their goals.

- If their goals are too high, they get discouraged more easily. Help your friend reset his or her goals to a sensible level. When the big is impossible, a lesser thing is acceptable. Accept a lower grade; write a less polished paper.
- Many students look at big tasks, set one big goal to do the whole thing, and feel discouraged. Help your friend to sub-divide the task into bite-size sub-goals that he or she can do one by one.

6. Encourage by talking about the high value of learning.

When students get discouraged, they often feel that it's not worthwhile to continue working. Your job, as a friend, is to remind the student that he or she really wants to get the results that come from continued studying.

- Don't just say studying is valuable. Say the results of studying are worthwhile.
- Help your friend to remember his or her deep values and goals. Turn your friend's mind back to the beginning of the term, before the trouble began. What were the goals then? All of us have real and deep

values within us; help your friend remember them. Values may be placed on knowledge, beauty, fun, or ability to help others.
- Suggest your friend visualize the good results that will happen from working and finishing the work. Suggest your friend imagine how good he or she will feel when the learning and skills are developed.
- Talk about the nasty effects that the student causes if he or she gives up now. It might be that the student gets a low grade, needs to repeat a course, drops out of a program. Count the cost of quitting. Encourage your friend to avoid the troubles that come with quitting.

7. Encourage by talking about possible change.

It gives people hope to think that things can change. Talk about possible things that can change.

- Later parts of the course will be easier than this part.
- Over time practice will build up mental skills.
- Periods of intense effort will be over after awhile. They will not last forever.

8. When not to encourage a person.

We've got to say this next idea: Sometimes students should drop a class. There are situations when it's better not to encourage a student. What are they?

- Don't encourage if the course content won't help the student reach his or her goals.
- Don't encourage if the student knows for certain that it's impossible to succeed. Three danger signals: lacking prerequisite skills, having a personal problem that prevents spending enough time on a class, and falling too far behind to catch up.
- Don't encourage if the student could succeed only by making a horribly massive effort and he or she has decided that the cost is greater than the reward.
- If you, as the student's friend, agree that one of these situations really fits, then help the student drop a class. But your job is to make sure that your friend has not exaggerated the problem. Discouraged people think negatively. They don't believe they have any control at all. They under-estimate what they can change.
- Your job as a friend is to help your student friend see in reality what things he or she can do, can control, can change and make happen.

Encouraging you, the friend, to act.

Many of you may ask: "Can I really make a difference?" Yes, research shows that students who have friends and relatives who encourage them succeed more often than other students. Research shows that even if you encourage "wrong" or do it just a little, it often helps. So act!

Study Tip #12 - HOW TO ASK QUESTIONS THAT HELP YOUR TEACHER TEACH BETTER

Outline on asking useful questions

1. Good questions help teachers.
2. Ask about the learning goals.
    - Memory goals: Recognition, recall and application
    - Skills vs. ordinary knowledge
    - Transfer the learning to new examples
3. Ask for a wide range of positive examples.
4. Ask for negative examples.
5. Ask for charts of concepts.
6. Ask for the big ideas.
7. About skills: ask for demonstrations.
    - Ask what the goal is for each step.

- Ask what stimuli signal what to do.
- Ask what the right actions are.

1. Good questions help teachers.

You have probably noticed that you can learn more easily from some teachers than others. Some teachers include several useful kinds of information; others leave them out. If you are alert, you can ask questions that bring forth this useful information and help everybody. Since a students build good memory by making firm associations, you may wish to ask questions that lead teachers to give information that helps you and other students make wise associations.

2. Ask about the learning goals.

When you read textbooks and listen to lectures and participate in class discussions and labs and do homework, you face a problem. There is too much to learn. There are too many possible things you can focus on: facts, definitions, theories, values, problem-solving skills, tasks of transferring knowledge and skills to new examples, and lots more. If you know the teachers' goals for you, you can focus your studying better. You can study what's important.

- **Question:** A simple way of knowing goals is to ask what's on the test. A better way is to raise your hand and ask in a friendly way, "I see there are several different types of knowledge here. What is most important for us to focus on?"

Memory goals: To recognize knowledge or recall it or apply it.

Recognition means knowing something, then seeing some things that are examples of it and others that aren't and being able to recognize which are really examples. Many multiple choice and true-false tests contain recognition questions. (True or false: The capital city of California is Sacramento.)

Recall means getting a question and pulling the answer out of memory. (Can you recall the name of the capital city of Oregon?)
Application means taking information and using it to solve problems or deal with new examples. (Use the fact that 2 + 2 = 4 and tell me how many bags of pine cones I will have if I pick two bags and buy your two bags.)
Teachers differ a lot in what kind of memory for knowledge they have as goals. You can often figure it out by seeing examples of past test questions.

- **Question:** Ask whether your memory goals are to recognize the knowledge or recall it or apply it.

Memory goals: The kinds of skills you will be expected to develop.

A skill is the ability to use knowledge and perceptions to do a task. Since the average teacher is more aware of teaching ordinary factual knowledge than skills, you can be very helpful by asking what skills are goals. For example, suppose a teacher uses comparison and contrast questions on essay exams ("Compare Wordsworth's theory of poetry to the theory of A. R. Ammons'). Students with good knowledge but weak skill in writing comparison and contrast essays could have difficulty. If they know in advance that they should develop that skill, they can study some models, practice, get feedback and grow in skill.

- **Question:** Ask what skills will be asked for.

Memory goals: To transfer knowledge to new examples.

When you learn knowledge and skill, you will have to use it on new examples you didn't study with. Sometimes it's easy. For example, you may learn to type on one keyboard and use your skill later on a different keyboard, but the skill is very similar. Sometimes transfer is hard. For example, you might learn to recognize a vine maple leaf in biology lab, but you might need to transfer your knowledge later outdoors when vine maple leaves growing under different conditions look a bit different. When you know that the teacher's goal is for you to be able to transfer your

knowledge to new examples under confusing conditions, your study strategy will be to study a lot of different examples.

- **Questions:** So ask about the goal of transfer. Also ask how the ability to transfer will be tested.

3. Ask for a wide range of positive examples.

Most teachers these days know they can help by giving examples. But many still just give one or two examples and move on. That causes students a problem because they need to know the full range of examples of a concept. They need to know the far out examples. For example, when you learn about mammals, you need to know that whales, who look like fish, are really mammals. When you learn about acceleration in physics you need to know what the acceleration is just as you throw a ball into the air, what it is at the peak of the ball's flight, and what it is when it falls.

- **Questions:** You can help your teacher by asking what the wide range of examples is. Ask for unusual positive examples, examples that students might not realize were examples of the concept.

4. Ask for negative examples of a concept.

It is rarer for teachers to consciously teach students what things appear to be good examples of a concept but really are not. A teacher could help teach mammals by teaching the negative example of penguins. In teaching the color mauve, a teacher could show examples of mauve first and then show negative examples, things that are not mauve, like lavender and fuchsia. A teacher could teach positive examples of rhymes (the end of words sound alike, pill and quill) and negative examples involving alliteration where the front of words sound alike ("nattering nabobs of negativism").

- **Questions:** A good way to ask about negative examples is to ask, "What things do beginners commonly get confused with the concept?" Ask for specific concrete examples, not for more concepts. If your teacher will answer honestly, you'll innocently steal a number of multiple choice questions.

5. Ask for charts of concepts.

Many teachers must teach sets of concepts. Some are general, some more specific. Think of the biological charts of species that you've seen. Some teachers just teach them in sequence. It is very very helpful to see how they are related, which are the general ones, what families they fall into.

- **Questions:** Ask your teacher to draw a rough chart or diagram relating the ideas and concepts together.

6. Ask for the big ideas and organizing frameworks in the current topic.

In many fields a few principles unite many small facts and principles. When students know these big ideas and when they relate the many specific facts to the big ideas, they can learn many times faster. For example, in Sociology many different topics are examples of the principle that "if certain people belong to a group, they learn that group's culture and tend to act consistently with it." It applies to small groups and big organizations, to race and class and gender, to institutions, social change and more.

- **Questions:** Ask your teacher what big ideas and frameworks to look for as you read. After a section of a lecture, ask if there is a unifying idea that summarizes a lot. (See Study Tip #3 on frameworks.)

7. About skills: Ask for demonstrations.

Every step in doing a skill has three parts: The goal, the current situation, and the right action. Many teachers give incomplete teaching of skills. They merely tell you what to do as if it were only a series of abstract steps. "Do this, then do that, finally do that." That leaves out telling you the goal of each step and what stimuli will signal that you should do that step. That also stops students from seeing the richness that comes from watching demonstrations.

As a student, you can help correct that by asking the teacher to demonstrate doing the skill on real examples. Math teachers do it all the time by working problems on the blackboard. Other teachers should do it, too. You can also ask for and study written examples of doing skills, i.e. sample problems in math. Or suppose the teacher has assigned a paper. Ask if a few good examples of that kind of essay can be put on reserve in the library. Ask the teacher to mark the traits that make these good papers.

- **Questions:** So ask the teacher to make comments while he or she demonstrates working through the problem naming goals, situation and action. Ask questions like: What do I want to do now (goal)? What is it about this stage that I should look for that tells me what to do (stimulus or situation)? When I want X and see Y, what is the right thing to do (action)?

Study Tip #13 - HOW TO TAKE OBJECTIVE TESTS TO GET THE HIGHEST SCORE POSSIBLE

Introduction

Objective tests are true-false tests, multiple-choice tests, matching tests and fill-in-the-blank tests. They don't ask you to write an essay. You have to respond to the choices given to you.

There are good techniques that you can use to get the most out of your knowledge.

However, remember that nothing beats studying! People who know their subject are able to get much higher scores on tests than people who are good at test-taking but who do not know the subject. So study!

Read carefully and get the exact meaning of words. This is the most important advice.

- Read slowly enough that you understand the meaning of everything that your present degree of knowledge allows you to understand. Many students read too quickly. When you read too fast, your brain will not have time enough to retrieve the meanings of words and phrases, and losing meanings is dangerous. When you are worried, be careful to read slowly.
- Read the directions carefully. Read until you understand them exactly. Do not skip the directions. Follow them! Successful test-takers are careful to read directions.
- There are several ways to know that you understand the meanings. (1) Talk to yourself and translate difficult words into your own words. (2) Make mental images of the ideas. Visualize them. (3) Imagine how things move and feel.
- It can be hard to understand uncommon words. You can often clear up their meanings by using simpler words and making a mental movie using them. Example: "A patient was moved from the prone position to the erect position." Visualize a person in a bed being moved from lying down to sitting up.
- Research shows that students often misunderstand words and phrases that describe relationships. When you see sentences which compare two persons, categories, times, situations, etc., then you should slow down. You can clear up their meanings by making a little table with a column for the traits of each thing being compared.

How to Recall Forgotten Information.

Here is a general way to recall information. You will prepare by going into "retrieval mode". It is a distinct way of thinking that helps memories come to the surface. Recalling memories always starts with retrieval cues: the words and ideas in the teacher's questions, your own translation of the words of the test into mental images and your own associations which finally trigger your recall of the memory. Here is retrieval mode:

- Prepare to notice your own thoughts and simultaneously to turn your attention away from the external world.
- Let yourself expect to need time—30 seconds to a minute in a test situation.
- Start thinking of additional retrieval cues related to the wanted knowledge. Think of more cues than the ones provided by the teacher's test question.

- As your mind produces associations, one will lead to another. Notice them. Follow them to the goal of recalling the wanted knowledge.
- If you cannot recall it after a brief hunt, let yourself move on and later return to the question.

On multiple-choice tests read all of the answer options before choosing one.

Why? Because the test might contain two answers that sound good, and only one might be precisely right. You need to check them all.

How to Handle a Time Limit.

- Check the time allowed and the number of questions. Figure out how many questions you have to answer each minute in order to finish. Try to work at that rate.
- Work first on the easier questions.
- Mark the questions that you have not answered and do them later.
- If you finish before the time is up, read over the test again and check your work.
- If some questions are worth more points than others and your time is short, consider doing them first.

How to Handle Questions That You Do Not Know the Answers to.

- Find answer options that you are sure are wrong. Eliminate them. Choose one of the remaining ones.
- Check whether two answer options say the same thing in different words. If they do, it means they both must be wrong, unless you are allowed to pick two correct answers.
- Check whether two answer options directly contradict each other. If they do, you know that one must be wrong. Possibly both. Use it as a clue.

Use key words as clues. Look for:

- ALL
- ALWAYS
- EVERY
- MUST
- NEVER
- NECESSARY
- NONE
- ONLY
- EXCEPT
- MAY
- OFTEN
- GENERALLY
- SELDOM
- PERHAPS
- SOMETIMES
- When you see sentences that claim something is ALWAYS or NEVER true, be suspicious. There might be exceptions. The teacher may be overstating a point to try to trick careless students. It is possible, though it is not certain, that an answer option with a word like that will be wrong.
- On the other hand, when you see sentences that say something may be GENERALLY true or PERHAPS true, remember that those words allow for exceptions and may be right.
- Be careful! Most teachers know that students know about those words. They might try to trick you.

It is Safe to Change Answers.

Should you change an answer if you are unsure of it? Yes, but not on a whim.

Research on test-taking has shown that people who change answers for a good reason get higher scores than people who stick with the first answer. But be sure you have remembered new information.

Should you guess when you are not sure?

- Yes, when you are not sure of an answer, you should make a guess.
- Why? Because if there are five possible answer options, you have a one-in-five chance of getting it right. If you have ruled out one or two options as wrong, your chances are even higher. But if you do not guess, you have no chance at all. If you guess on five questions, you may get one or two more right.
- Even if the directions tell you that there is a penalty for guessing, you should usually still guess. It will usually improve your score.
- Why? Because all that a guessing penalty does is to subtract a certain percentage of wrong answers, and you might be right. The worst that usually happens is that you will come out even. So guess!

How to Cope With Feeling Tired, Nervous, in Pain and Other Stresses.

- When people are under stress but are able to concentrate, they can do almost as well on tests as when they are relaxed and feeling fit. Your mind may wander. But make sure you keep returning your mind to the test questions. Keep thinking of their meanings. Keep thinking of associations. As long as you can do that, you have a fair chance of succeeding.
- If you are jumpy, use your finger or your pencil to guide your eyes along the words of the questions.
- Handle mechanical details carefully.
- Mark answers carefully. Don't accidentally mark the wrong answer.
- If your teacher has you answer on an answer sheet that will be scored by an automatic scoring machine, make your marks heavy and dark.
- Do not make stray marks elsewhere on the answer, because the machine may mark them as wrong answers.
- If you have to change an answer, follow the directions carefully so that the machine does not pick up the answer you changed.

What to Do If You Think the Teacher Has Made a Mistake.

- Sometimes, teachers write bad questions. You may read a question and think there are two answers or no answer. Sometimes, you will see ambiguous wording.
- If the teacher permits students to ask questions during the test, you should ask!
- You may also write a note to the teacher. (Do not write on a machine-scored answer sheet.) You should explain your thinking. Explain why you chose the answer you did, what it meant to you. Explain why you rejected another answer that may be the obvious choice on the surface, but that contains a trap. If you do this, your teacher may give you part credit even if you are partly wrong.
- When the teacher returns the test and reports the correct answers, you may wonder why an answer is correct and why your choice is wrong. It is all right to ask respectfully why the teacher thinks it is correct.
- Don't be hostile. An honest teacher can either explain it or will admit a mistake.
- If you still believe that your teacher has penalized you unfairly and will not change, then consult your school's Student Bill of Rights and follow the procedure to make a protest.

Get more help on test-taking methods.

Take Effective Learning in the Academic Learning Skills Department. You can also buy one of several commercially published books on test-taking skills.

Study Tip #14 - HOW TO PLAN YOUR TIME SO THAT YOU CAN GET YOUR HOMEWORK DONE

Put a high priority on doing schoolwork.

Most people's problems with "not enough time" are really decision problems. Is your time problem really caused by your choices?

- Many people don't like to study, so they put a low priority on doing their homework. When they get free time, they choose to do leisure and family activities that feel important.
- They cannot get their schoolwork done and must work hard at the last minute. They complain they don't have enough time! Wrong! They had rated school work as low in importance. They had treated schoolwork as lightly as any sensible person would treat a low priority activity.
- Suggestion: Decide that you feel it is very important to do your school work. Then you will automatically begin to have more time for it.

Use three kinds of time planning reminders.

Many busy people use all three kinds of planners:

- **To-Do list.** It is notes on tasks for that day and the future, such as phone calls to return, errands, ideas. You make a detailed list, add new things that come up during the day, include small things and derive others from your long-term schedule.
- **Long-term calendar**. It marks the due dates & times of assignments, tests, papers, appointments, and other events on a calendar.
- **List of bigger projects**. It lists on one sheet of paper all the big tasks you must keep working on. Often these lists indicate priority, the next steps, due dates.

Plan a master schedule at the start of each term.

Include the times each day that you read and do homework. Students who carry a course load of 12 credits will often schedule 10 to 30 hours of homework outside of class each week. A week has 168 hours.

How to make a daily "To-Do" list.

- Write down everything you need to do. Put both school work and other activities on it. Then rate each item's importance.
- Put "A" beside activities that are highly important. (Most people use the left column.)
- Put "B" beside activities that are somewhat important, but are secondary in comparison to "A" activities.
- Put "C" beside activities that would be nice to do, but are not as important as the "A's" and "B's".
- Then throughout the day, work on only the "A" activities until they are done.
- Rate most schoolwork as an "A".
- Rate assignments with future due dates as "B" or "A" priority.
- Put relaxing time on your "to-do" list. It is important to give yourself time off to lead a balanced life, except possibly for doing brief periods of intense work. If you do not schedule times to relax, you may end up hating your work, rejecting it and plunging into fun activities.

Use your knowledge about the psychology of learning to plan time.

Here are three facts about learning that relate to time:

- People can learn with the lowest amount of total study time by studying topics in many spreadout work sessions. The same spacing effect is true when practicing skills, such as a sport, doing math, solving physics problems. In contrast, working in a few long sessions is less effective.
    - Suggestion: Plan to make several contacts with the same material spread out over several days.
- Certain memory tasks take longer than others. It takes most people longer to learn information that is not very meaningful to them. Examples: new vocabulary, symbols, proper names, numbers and dates, and material in a

new field. In contrast, people can quickly learn highly meaningful information.

    - Suggestion: Schedule more total time to learn less meaningful information.
- It takes a long time to build skills and do them with greater speed and higher accuracy. You will be learning skills any time you must learn to do such tasks as solving problems, writing essays, and performing procedures.

    - Suggestion: Plan to spread out your practice of skills over days, at least. In contrast, you can memorize information in fewer sessions.
- Plan time at the very small level of reading sentences, paragraphs and passages. Plan to read and pause and review in repeated cycles.
- Plan time when taking courses in math, science and other subjects that require solving problems. Plan to do some problems right after reading the text or taking notes on how to do them. Such quick use of your new knowledge will trap it while it is fresh and help you solve problems.
- When solving problems plan enough time to let yourself pause after each problem is finished to do two things: To review the steps you took (to strengthen the memory) and to praise yourself and feel good about using the techniques successfully (to give yourself positive reinforcement).
- Use your knowledge of the rapid fading of information from working memory and of fading of weakly learned associatiions as a basis planning the times when you review.

Plan time for large assignments by dividing them into parts.

Analyze the tasks involved in such large assignments as papers and big study projects. Break them into small parts. Starting with the last task, work backwards and schedule time for each part.

The purpose of this advice is to help you guarantee that you plan enough time to finish a big task. If you do not plan, you may think the task is shorter than it really is. Then you will put it off, start it late, and have trouble.

You will need to estimate three things:

1. What are all the tasks you need to go through to finish the assignment?
2. How long will each task take?
3. When will you need to do each early task in order to make enough time to do the later tasks?

An example:

Suppose you are writing a short paper. The steps are: read the assignment, take notes, think about it, write an outline, write a first draft, edit it, and write a final draft.

If your paper is due Monday, ask yourself when you need to start writing the final draft (the last task) in order to be done on time. Next ask yourself when you should edit your first draft (the next-to-last task) in order to allow time to write the final draft. Next ask about writing the first draft. And so on. Work backwards from later steps until you schedule the first step of reading.

Start big projects by doing "foot-wetter" tasks.

Some projects look so huge that people find it hard to start them and keep putting them off.

- You can often get started by picking out an easy part of it to do, the "foot-wetter." Once you start, you can continue easily.
- Schedule a short work-session. The purpose is to make it seem easy, not hard.
- Do easy things: get the books together; take out the typing paper; and read the class notes.
- You can also find something in the middle of the project to do. You don't need to start at the beginning. Many good writers say that they start in the middle and later write the first paragraphs.

When you get short periods of time, work on short parts of longer assignments.

- Do not wait for long blocks of time to come open before you study. Your penalty for waiting for long time periods comes in yout waste of short time periods that you could use for studying.
- Read three pages while waiting for the bus. Write one paragraph for an English paper while waiting for a TV program to start. And so on.
- You may wonder whether people's minds can handle broken-up periods of work. Yes, they can. As you start, remind yourself where you were in the task. Do a 1-minute review to warm up your memory for the task.

Learn to say "No" to people who try to interrupt you.

When people suggest that you do something with them, they do not usually realize how necessary and important it is for you to do homework. So as you say "No," explain it to them. If you promise them some time later, they will usually accept it.

You will have to pay a price in order to manage your time successfully. Some people will feel dissatisfied with you, and you will feel frustrated when you give up doing certain things you like. Are you willing to pay that price in order to get your education? Only you can decide.

Do your most difficult school work during your best time of day.

Many people know that during certain times of day they work faster and think more clearly than at other times. They know that they are slow or sleepy or grumpy at other times. You should notice what times are good and bad for you.

- If you are a "night person", then night is when to write your papers and to read the deep books. Do easier work at another time. If you are a "morning person", use morning for creative work and hard work. You will accomplish more.
- Do not do ordinary, routine homework during the time that you are most alert. Save the best time for the hardest work.

Follow the "Work First" rule.

Some successful students do not schedule their time at all. How do they do it? They put schoolwork ahead of everything else almost all the time. So they usually get it done.

- The rule: When you have school work waiting, always do it ahead of anything less necessary.
- Don't be silly about this rule. Of course, you can eat, sleep, and mow the lawn on Saturday.
- People who follow this rule never put things off. They don't procrastinate. They start new assignments immediately. Frequently, they get their work all done early and they have free time for play that they can use without feeling guilty. Some people say that the biggest benefit of using the "work first" rule is that you don't feel guilty when you do something else.

Study Tip #15 - WHAT MOST INSTRUCTORS EXPECT THEIR STUDENTS TO DO

Introduction

If you know what your teachers expect, you can adjust how you act toward them and get more success in college. You don't have to do everything teachers expect, but it helps to know. This sheet will tell you what college faculty usually expect.

Instructors assume student freedom.

- Most college instructors will judge you to be an adult. They usually will not think of themselves as having authority over people. This is not high school or the army. (But you may still meet a few instructors who are authoritarian.)
- Most instructors know that you and most of the students chose freely to come to college and to take courses. They know that they cannot force or compel students to do things. They know that students have the right to quit whenever they want to. Most instructors accept the fact of student freedom.
- If you make choices that are bad for your education, most instructors will not interfere. Therefore, you will have a lot of freedom to get into trouble. And you will have to get yourself out of it. For example, if you cut classes, stop doing assignments, and miss a test or two, most instructors will not try to change your behavior. (However, a few will check what's happening.) So decide to supply your own self-discipline.

Do a lot of work outside of class.

- Most college teachers deliberately plan their courses so that you and the other students will do most of your reading and learning outside of class. Of course, teachers vary. You may take courses that do not require outside reading and studying. But that is rare. Do not plan to try to get through most courses by simply going to classes and skipping the reading and the rest of the assignments, because you won't learn enough to get good grades.
- Do buy textbooks and read them. Yes, their prices are rising and that is a big drawback. But you will find information in textbooks that is not covered in class and you can go over it again and again.
- When instructors say in their syllabus to "read" certain pages, they mean much more than just "read". You will need to find concepts, principles and examples of them. You will need to bring together related ideas and concepts that are spread over many pages. You will need to find big ideas, major principles, and organizing frameworks. You will need to translate verbal knowledge into steps to use in cognitive skills.
- Instructors often expect students to learn a lot of knowledge as they go through the course day by day and week by week. Early information is often the foundation for later material. Instructors will expect to do the fundamentals of learning: to learn accurately, to associate various parts of the incoming information with each other, and to review your knowledge to make it firm. You will need to memorize certain things. And more. Expect to study as you go along. Avoid procrastination. See earlier study tips for more information.
- You should plan on doing a few hours reading and study each week for each course that has reading assignments. And you should plan on needing extra time when teachers require written papers and homework. Finally, you should allow for a few hours of review to prepare for each test.
- Many students who get poor grades simply do not realize how hard the students work who get high grades. Some can study 10 to 15 hours a week outside of a difficult class. More for very hard classes! (Most classes are much easier.)

Do homework and reading assignments on time.

- Teachers generally expect (and hope and pray!) that you and other students will do your homework and reading assignments on time. A teacher's whole plan of teaching usually depends on the students being up-to-date with their reading. When the students all know a certain background, teaching works best, because the teacher can talk about more complicated material that depends on the students' knowing that background information.
- Students who have not read the assignments have a difficult choice: Either they must sit quietly and not understand ideas or they must ask about simple facts that they should know already.
- Many teachers give out an outline of the course with the assignments on it during the first class period. Often they will not talk about the assignments after that. Teachers will expect that you will read the outline and will do the assignments, and often they won't remind you about assignments. If your teacher acts this way, don't get fooled and fall behind. Check the outline and do your reading.
- Most teachers expect students to do the homework and take tests on time. Teachers have many different tasks to do. If students do their work late, it takes longer for the teacher to grade it fairly because the teacher has to take time reviewing the key ideas and the standards for grading.
- Naturally, most instructors will give you some flexibility, and they all recognize that students can face difficult situations which cause them to do work late. So set the goal of doing your work on time, but if occasionally you can't, be philosophical about it.

Ask questions in class.

- Most instructors expect that you will ask questions about the things you don't understand. If you are silent and shy, most instructors will misunderstand you. They will think that they made clear explanations or that you are bored and don't care enough to ask.
- It is common for students to feel nervous about asking a question in class. They are afraid of asking a "stupid question". They are also afraid of interrupting the teacher's presentation and irritating both teacher and students. The oldest excuse is, "I thought I was the only one who didn't understand and I didn't want to slow down the class." Often several students wonder about the same thing. And generally teachers welcome students' questions.
- Asking questions and hearing answers helps memory because the questions gets associated firmly with the answers in your mind.
- You should ask your questions when they occur to you, unless your teacher says not to. Don't wait. Why? It helps you. It helps the other class members who have the same question. It helps the instructor know how clearly he or she is explaining the ideas.
- Plan certain questions in advance for maximum usefulness. If you read your textbook on the day's topic before class, you can pinpoint difficulty and plan questions. Write them down. (See Study Tip #12 on some good questions that build memory to ask instructors.)
- When you ask questions, stay on the subject. Honor the norms that no one student should talk too much. However, apart from these warnings, you should talk in class. After all, you are paying good money to buy this knowledge and these skills! So insist on getting your money's worth. If the teacher wants you to lessen the number of questions, let him or her tell you.

Visit your instructor's office.

- Our college requires most instructors to be on campus a certain number of hours per week and to keep office hours so that students can visit.
- So when you have trouble understanding certain ideas and when you have longer questions that you don't want to ask in class, you should visit the instructor. It is perfectly right and proper to visit an instructor's office.
- Most instructors welcome students. They see the students who visit them as motivated to learn.

Take notes in class.

Students usually can learn more and learn it more effortlessly by going to class and taking notes. So attend classes. Take notes. Instructors usually give information in class that you will not find in your textbooks. They will expect you to learn things from class lectures and to answer ques¬tions on tests. So buy a notebook and take notes.

Some students misunderstand the way the memory works. They are fooled by the fact that they understand a teacher's ideas, so they think it means that they will remember the ideas without taking notes. But that is wrong. It takes a different kind of studying to remember information than it does to understand it. Students who don't take notes tend to forget details, lists of things, complex arguments, and material where it is important to remember the exact wording. So take notes! See the Study Tip on note-taking for suggestions on how to take good notes.

Be an active learner.

- Teachers expect their students to actively try to learn. They will not expect you to be passive.What is an active learner? An active learner desires to learn a topic, asks questions and searches for information to answer the questions. Such a student tries to understand new ideas, practices new skills many times, and tries to see how new ideas are connected to each other and to familiar ideas. Active learners try to memorize important principles and information. And such a learner tries to use the new skills and knowledge in real life situations.But a person who learns passively expects the teacher to pound in the new knowledge. He or she expects wrongly that he or she can relax and listen without thinking.For example, one of our teachers had a middle-aged man in class who had worked in a factory running a machine. At work he was able to let his mind wander and work automatically without paying attention. In college he expected to do the same thing. So he sat back, detached his mind, did not try and did not think. Naturally, he began to get low grades. Fortunately the alert teacher noticed his behavior and explained to him why people cannot learn

things unless they become mentally involved. He listened, changed his behavior, and learned rapidly after that.You can find out how to become an active learner by using the techniques described in these study tips.

Study Tip #16 - PEOPLE OVER 40: LEARNING AND MEMORY

What Changes When As You Get Older?

As people move into their 40's and 50's, many, but not all, of them notice memory problems. They may find it harder to learn new things and may forget where they put things: glasses, keys and purses. Since many people have now heard about Alzheimer's Disease, they wonder if these common symptoms mean they are going to get it. (No, most of us won't.)

People vary in their memory ability. Some in their 70's and 80's seem to learn and remember things as well as younger people, while others may begin to have problems in their 40's. As the psychologists say, over 50% of people over 50 eventually suffer from "age-associated memory impairment." Fortunately, there are many things you can do to improve your memory.

The same principles of memory still work for older people but they have to be used for a longer period of time. Older people can still learn when they get new information understood accurately, make associations between new and familiar knowledge, and make the associations firm and long-lasting.

Some Kinds of Memory that Age Affects

- **People cannot recall new information as well as they get older**. Some examples are people's names, new words, technical vocabulary, phone numbers, abbreviations, acronyms, and formulas. Such items are intrinsically meaningless because they are symbolic, and even younger adults cannot learn such things as easily as they can learn meaningful information. It's even harder for older adults. Nevertheless, even as people age, they can comfortably and quickly learn meaningful information that builds on their current base of knowledge.
- **People find it gets harder to recall the names of familiar people and places**. Similarly, recalling a seldom-used word can stump older people. As people age, they get more mental blocks and substitute roundabout ways to say what they want.
- **People find it gets harder to recall personal events** that have happened in the recent or middle past. For example, when writing a letter, it may get harder to remember what you did. Yet memory for certain childhood events may stay strong.
- **People find it gets harder to remember changed facts**. When an organization changes its name, when a TV show changes its showtime, when old health information is changed by new research, older people have a harder time learning the new.
- **As people get older, it takes more time to learn new and difficult things**. They need to take longer to learn new knowledge or to practice a new mental skill and get it learned up to an acceptable standard. The person over 40 can get there but needs extra time.
- **People can have more difficulty doing two tasks at once**. As people get older, they go slower and make more mistakes when their attention is divided. Or in order to do one task well, they have to sacrifice their speed and accuracy on the other. And the harder the two mental tasks are, the more difficult it becomes to do two at once. School provides a good example. Listening to a teacher's lecture involves three tasks: (1) Listening for understanding, (2) creating a mental summary of it and (3) writing it down as class notes. That means the 20 year-olds may take better notes.
- **If people work** in a white-collar job that requires learning new information and remembering many facts and names, their ordinary memory decline may hurt their work more.

Some Kinds of Memory that Stay the Same as People Get Older

- **Older people can and do learn new things** constantly, even totally new things, even hard facts, vocabulary, names and mental skills. In fact, if an older person takes the 20 or 30 percent extra time required and learns something to the same standard a younger person does, the older person will retain the ability at the same level.

- **Short-term memory stays about the same**. For example, older people can hear a phone number and retain it long enough to dial it, and they hold about the same number of new facts in their heads.
- **Well-learned information and skills usually persist**. As people age, they can usually cook, read, do math, drive cars, etc. about as well as when younger. On the average, abilities persist into the 70's or 80's. There is a lot of variation among older people's memories.
- **People's memory for the meaning of things, for how the world works, tends to persist**. People don't forget what cars and grocery stores are, the law of gravity, or what senators are. Although they sometimes have trouble re-calling a car's brand name or their supermarket's name or Sir Isaac Newton or the name of their state senator, they understand what is going on.
- **People keep their ability to recognize names and words** even when they cannot recall them on demand. "Who's that guy who discovered the law of gravity?" "Newton." "Oh, yes."
- **People keep their ability to intend to do something and to do it**. It is when an older person thinks too automatically of a task that forgetting occurs.
- **The average older person can do better than younger people at analyzing complex problems that lack clear right or wrong answers.** They can handle ill-structured issues and can ponder them from various perspectives, using broad patterns from their memories to draw wise conclusions. They often have better judgment than younger people in ambiguous situations.

Eight Ways You Can Help Your Memory

- **Slow down your speed of reading and thinking**. Spend a little extra time on each phrase as you read. Why? When you take a little extra time, it increases the mental energy your mind can use ("activation", as the psychologists say). This extra energy recalls meanings, makes associations to related things, and raises the odds you will remember what you read.
- **What reading speed should you change to**? You can decide by noticing at what speed the meanings become clear to you. And when thinking, you can notice when ideas become sharp, crisp, precise and well-defined. Stay on a topic until that happens. Don't think quickly and jump.
- **When you learn new information, focus on what it means, on its significance**. Use the wide experience that comes with maturity to add meaning to what you read and hear. Why? When we think about the meanings of new things, we create memory. And if you later forget the exact words, you can use your knowledge of the meaning to remember ideas.
- **Use memory tricks and other ways to associate new information to other ideas**. Turning words into pictures has special power. The keyword method (see Study Tip #6 on memory tricks) does that and so does elaborative interrogation. (Ask yourself "Why does this make sense?" and think of an answer.). See some of the other Study Tips for more suggestions.
- **When possible, do just one mental task at a time while learning**. When you read, pay attention. When you listen to a lecture, try to take notes on important things while the teacher says less important things. (Yes, I know it's hard!) After something distracts you, return and concentrate. Try to be alone and away from competing noises, sights, feelings, and thoughts. That will build mental intensity and help memory.
- **Take notes**. Write things down. Make lists. Put into notes the things you know you tend to forget. Jot down stray ideas, names, technical terms, etc. Carry a pen and notebook.
- **Live in the present and pay attention to what you are doing**. Don't let your mind go idle or daydream while you do familiar things. Instead, let your attention follow what your hands and body do. For example, as you drive into a parking lot and park on a foggy morning, pay attention to the little habits of shutting off the car and you may also remember to turn off your headlights. If you do things just a touch slower than you need to, you can boost your chances of staying rooted in the present.
- **Decide to accept yourself. Accept the physiological changes that are happening to your body and your brain**. Now why did I say an obvious dull thing like "accept yourself"? Because people who hate aging and fight it will spend time thinking angry or depressed thoughts. Those extra thoughts steal your precious mental time needed to notice and think and remember. Remember that doing two things at once lowers your mental efficiency. Be simply at peace. If you accept yourself you will free your brain to do what really counts: to pay attention, to think of meanings, to slow down, to use memory tricks.
- **When you try to recall a forgotten name or fact, think of other things connected with it**. Don't poke in vain at that feeling of the forgotten name. Instead, focus on what else you know about it. Think about those things. For example, once I forgot pschologist Fritz Perls' name. So I remembered his book on Gestalt Therapy. I visualized its white cover. I thought of some of his methods. But it seemed to fail. So I thought of other things . . . and two minutes later I had his name! Usually it works even faster.

Practice These Things One At a Time.

How are you going to remember all this? Even a 20-year-old can't. And no one learns without practicing. Pick one good suggestion. Practice it at home. Then after getting familiar with it, try it in real life. It's inevitable that events will distract you and you will forget to do it. But when you remember again, just simply try again. Your step by step practice will grow a habit.

Study Tip #17 - RAISING YOUR INTELLIGENCE

Introduction

People used to think that their intelligence was unchangeable. But psychologists now believe that part of intelligence involves skills we can learn. We can do exercises that will make us smarter. Just as athletes can practice and improve their skills, so you can practice and get smarter!

What is Intelligence?

- Intelligence involves two abilities.
- It means that we can see relationships between things. When we look at particular examples, our intelligence helps us think of general concepts and principles that link them. And when we see general concepts and principles, we can think of specific examples. Notice that perceiving relationships is the same activity as in all learning: making associations among chunks of knowledge.
- Intelligence also means that we can see relationships with abstractions. What are abstractions? They are ideas and concepts about things. They are not the sensations we sense directly by seeing, hearing, smelling, tasting and touching things. Instead, they are ideas about common traits that a group of things share. Seeing relationships with abstractions is another way of making associations, a more subtle way.
- For example, if you feel one flat desk, your fingers are feeling its flatness, roughness, hardness, etc. Those are sensations. But after you have felt several desks and can think of the general concepts of flatness, roughness, and hardness, you are thinking of abstractions. These are associations among several examples of properties common to several desks—a higher-order of associations.
- Another example: if you see a group of people, you have a sensation. But if you think the idea that they are a family, you have formed an abstraction.

Some Examples of Thinking Intelligently

- Here is a problem: "Name three ways that a tree is like an ice cream cone." Here are some of the many possible answers: Both have weight, both are larger than an ant, and both come in different colors.
- Did you notice that the answers involve relationships between trees and ice cream cones? The relationships were the three kinds of similarities: weight, size, and colors. Concerning abstractness: When you think of weight, it is abstract, because you have thought of weight by itself, as a separate property common to both trees and ice cream cones.
- Solve this analogy: "A cat is to a kitten as a butterfly is to a _____ (fly, moth, caterpillar, mosquito)." The answer is caterpillar because it's a young butterfly like a kitten is a young cat. Notice that you have to think abstractly about adults and youths.

Raising Your Intelligence

The major way to raise your intelligence is to practice thinking about relationships among things and to practice noticing abstractions. The more you practice, the more you will learn.

1. **Take courses that require you to think.**
   Try to do high-quality work. Courses that only give information or only teach a physical skill will not raise your intelligence much.
2. **Read a lot of books.**
   Choose books that challenge your ability to understand them. Slightly hard for you, but not impossible. Work at

trying to understand them. But be sensible. Choose books that are within your present ability--not too hard, not too easy. You can find relationships and notice abstractions in both fiction and non-fiction. Even "junk fiction" can help (romances, spy novels, Westerns). When you read complex books, think. Look up words you don't understand. Work to figure out hard passages.

3. **Write a lot.**
   Write descriptions of events that have happened to you and descriptions of things you have seen. Try to make the reader come close to understanding what you have thought and felt. Try to use the best words and most descriptive sentences you can invent. Use metaphors and complex analogies. Notice similarities across distant domains of human experience—the physical, the realm of feeling, pure thinking, and time and space. Writing will force you to think of relationships and abstractions.
   - Write a personal journal or diary.
   - Write letters to friends.
   - Write poems and stories and essays.
   - Take a writing class and work hard.
   - Keep writing over a long period of time, and your skill will rise.
   - Study other writers to learn how to write well yourself. Ask others to comment on your writing. Use their input to improve.
4. **Ask yourself questions and try to answer them.**
   Develop the habit of asking questions about how the real world works and about the similarities and differences between things. Try to answer your questions. Try to test your answers by seeing if they are consistent with other information that you have about the problem.
   Even if you cannot answer all your questions, your intelligence will grow because when you ask questions, it leads you to notice relationships.
5. **Do imaginative reading.**
   Pick a poem or story or article that is somewhat difficult. Get a dictionary. Then read one line. Now look at the important words and try to imagine what each one means. Talk to yourself or write down your thoughts. (Talking and writing help to clarify your thought and are important.)

Look for two things:

- What each word means.
- How each word relates to the rest of the sentence, paragraph, and where else it applies.

Read the following example and see how to do these things on a line from a poem by William Wordsworth.

"I wandered lonely as a cloud."

Notice that the person is the poet. "Wandered" means that one walks in a path that has no goal; one changes direction from time to time. "Lonely" means being alone and not liking it, wanting company. And it is "lonely as a cloud", not just lonely. "As" means similar to. What is lonely about a cloud? Can you visualize a cloud? Can you see it lonely? Can you imagine Wordsworth walking that way?

- Try hard to be truthful as you interpret the words. Check for accuracy.
- Read out loud and talk out your thoughts when you can. Write them down if you are willing. Talking and writing focus your mind.
- When someone else will do imaginative reading with you, it becomes a lot of fun. Take turns. You read a line and interpret it. Then the other person does it. After each one's turn, let the other add ideas.
- Expect your improvement to be slow at first. Don't worry about it. If you do it daily or several times a week for a period of time, you will get smarter at seeing relationships.

6. **Do mental exercises.**
   You can choose objects and practice several systematic ways of thinking about them. They use common relationships that intelligent people often think with.

   - **An object and its parts**. Think of anything and analyze it into as many parts as you can. Example object: A table. Some possible parts: Top, 4 legs, braces, plastic covering, molecules, atoms.

- **An object and its traits**. Think of anything and think of its traits, characteristics, and qualities. Example object: A table. Its traits: Its colors are green and gray, its texture is smooth, its shape is flat, its tem¬perature feels cool, its shape is square.
- **An object and its categories**. Think of anything and try to think of many categories that it fits into. Example object: A puppy. Its categories: young things, dogs, mammals, pets, someone's possession, a living thing.
- **A category and specific examples**. Think of any general category and think of many specific instances, examples, and illustrations of it. Example of category: Buildings. Instances of buildings: My white house, the LCC Center Building, the Washington Monument, an igloo, a mud hut.
- **A cause and its effects**. Take any event that could cause effects and try to think of many effects. Example of a cause: The eruption of Mt. St. Helens. Effects: The mountain's height was lowered, it dropped ash on cities, it killed people, it made interesting news, it aroused fear, it led to a visit by President Carter.
- **An effect and its causes**. Start with any event and try to think of many causes. Example of effect: Mashed potato hit the floor. Causes: A baby threw it, the law of gravity worked, no one grabbed it in time, the baby's eyes saw it, the baby wanted to throw it, the mother gave it to the baby.
- **Use computer software that trains your attention**. There are now many companies that claim they can boost your intelligence. Some are good and some poor. I have heard good things about the program from Posit Science Corporation. Try this website: http://www.positscience.com/. They give an explanation of how it works but—warning—it costs ample money to buy.

7. **Work on content that interests you.**
   When ideas interest you, you will learn faster. Research proves it. Having fun will encourage you to keep practicing. The more that you practice finding relationships and abstractions, the more you will be able to think intelligently. Practice, practice, practice.

Study Tip #18 - HANDLING TEST ANXIETY (Part 1)

Topics

- Influences on feelings of worry and safety
- 8 methods to help you feel safe in a test
- More topics in Part 2. See Study Tip #19.

Influences on feelings of worry and safety

One key to lowering test anxiety is to lower your belief that you will be seriously harmed. Stress is the anticipation of harm, says psychologist Richard Lazarus. So when we expect to be hurt, damaged, injured, we are expecting harm and we feel stress, one sign of which is feeling anxious. When taking a test, we sometimes know that we might do poorly, which can mean harm, and we often feel anxious. We can help ourselves by thinking thoughts to lessen our belief that we will be harmed.

Thoughts That Help Us Feel Safe

Since you will be using thinking methods to help your mind feel safe, you will need to assess if you can think on command. Please think the following thought and notice if you can do it. Think of a red house with a green roof. Now think of three parts of the house I didn't mention. Now think about counting from 1 to 10 slowly and return to thoughts of the house and its parts. Well, can you do it? If you can, the thinking methods may work for you.

There is a psychological principle that you will use: If you think of something, your cooperative mind will automatically start to bring to mind other bits of knowledge, feelings, and motives linked in the past to that first thought. You will handle test anxiety by choosing to think of things that lead to knowledge of safety and safe feelings.

1. **Think that the amount of harm is low.**

Have you noticed that when you think that very bad things will happen if you do poorly on a test, your anxiety rises? If you think that the amount of harm is high and intense and that you expect severe damage and pain, you will worry

more. By contrast, when you think that the harm will be a small amount of damage to you, you will worry less. So try these thoughts.

- Think realistically first about what is the worst thing that can happen on this test. Then think second about the days and weeks and months coming after that worst thing. (It is important to project ahead to the time well after the test.) Think: "I choose to accept it, if I have to." Then think third about what you can do to improve on that worst outcome. (This technique is so powerful that Dale Carnegie, author of How to Stop Worrying and Start Living, rated it as one of the top three methods.)
- "I can take it." Think that, yes, it will hurt to do poorly on a test and you won't like it, but that you are strong enough to endure it.
- "I've suffered worse." Think of the past things you have endured, and perhaps like most of us you have endured far worse things and survived, perhaps triumphed. Use that knowledge to feel safe. Use your visual memory to "see" the past thing as big like a mountain and your current test as a little hill. Use feelings to feel the past thing as big and the current test as small.
- If you can think these thoughts, you will help convince your mind that the amount of harm is low enough that you can feel safe. (Remember to prepare and practice these thoughts for days in advance of a test so that you can easily recall them in the middle of a test.)

2. Think that even if a test failure could be harmful, you can prevent it because you have a lot of abilities, a lot of things you can do.

Perhaps in the past you have noticed that when you think that you are stupid and incompetent, unable to learn the material, unable to remember what you studied, then you believe you are helpless and have no way to fight the damage that comes from doing poorly on a test. Instant test anxiety! In contrast, when you think about what you do know and about the abilities you do have, you will start to have safe feelings. We all have some strengths and weaknesses; the glass is half full and half empty. Worriers think of all they don't know; calm people think about what they do know.

Think of the topics you have studied and know. Think of your general abilities. Think about your knowledge of how to handle test anxiety.

3. Think that even if a test failure could be harmful, you can prevent it because you have helpers, friends, and forces on your side.

The prior suggestion was about your ability; this one is about resources outside of you. Think about:

- "I have plenty of time."
- "The teacher is fair."
- "People often have second chances."
- "When I study, I know that the normal laws of learning will help me learn."
- "Even if I miss a few questions, I can still pass."
- Investigate the backups available to you. You'd be amazed at how students who do poorly in tests, courses and programs, find ways to come back by help within the system. Use this knowledge of backups to help you feel safe.

4. Think about other things than the harm.

Even if you could be hurt by poor performance on a test, you don't have to think about it. You can think about other things. Many people deliberately turn their mind to other things and that weakens the strength of the worry.

- During the period before a test, when you notice yourself thinking about failing, turn your mind to pleasant experiences. It is normal for your unconscious mind to keep sending thoughts of worry to your mind. Just keep turning to the other experience.
- During the test, when you notice yourself distracted and worrying, pull your mind gently back towards the question you are working on. Do not criticize yourself for worrying; just keep your mind wordless as you turn your attention back to the question. Reason: If you criticize yourself, your obedient mind will associate to additional thoughts about how bad you are and return those memories to consciousness. Many people say something like, "Stupid idiot. I can't even pay attention." Your mind then associates to your past memories of doing stupid things and recalls how those bad times felt. That makes you feel bad both for the present and for the past! Who wants that?

5. Think that the harm is far away in the future.
When we know that trouble is coming but that it is far in the future, we feel safer than when we think trouble is immediate and near. So you can make mental images of the test as far away, so far that it seems blurry and unreal. When your worried mind makes it seem near and large and bright, make your visual imagery send it far away and small and dim. Say such distancing words as: "It's not until tomorrow." Combine the practice of not thinking about tomorrow with the sense that the future is distance and you'll lower worry. (This is another of Dale Carnegie's top three methods: "Live in day-tight compartments.")

6. Think that the events signaling possible trouble are merely normal expected trouble, nothing unusual.
It is a principle regarding emotions that when we define events as surprises, interruptions, and obstacles, we feel intense emotions. In contrast, if we define events as just normal expected events, we take a relaxed attitude towards them. When bad things happen while you take a test, keep thinking, "That's normal. It's expected. It's common."

- "I expected some difficult questions."
- "Some people are already done, but I expected I'd go slowly."
- "Yes, I'm stuck on this problem now, but some problems need several tries."

7. Think that you have such important goals that you are willing anyway to expose yourself to the dangers of taking tests.
When people see a loved one in danger, they often expose themselves to things they are intensely afraid. I've seen a woman who is intensely afraid of snakes rescue her curious cat who was walking too close to an 8-foot snake. I've read about parents rescuing their kids from oncoming cars. And you can use your strong goals for learning material and getting an education to help you face tests. You must remember those goals and think about them and think about why they are worthwhile. You will have both self-oriented goals (making money and a name for yourself) and generous loving goals (providing for loved ones and using your skills to help others live better lives).

8. Avoid other anxious people before a test so that they do not infect you with their anxious thoughts.
You have probably noticed how strongly other people can affect us. When you hang around anxious people, you may pick up their worries and start worrying yourself. So stay away from them.

Study Tip #19 - HANDLING TEST ANXIETY (Part 2)

Topics

- 4 influences on feelings of worry and safety
- What to do in a major anxiety attack
- How to prepare the methods for use and practice
- Four ways to influence your feelings of worry and safety.

1. Methods for weakening habits

When people have responded the same way to a situation for a period of time, they learn a habit, and habits can be hard to break. Many of us have grown a well-practiced habit of thinking we will be harmed by tests. So another way we can help ourselves is to weaken the old worry habit and to practice the steps of better thinking habits about our safety during tests.

When we have a habit of thinking that tests will harm us and raise our anxiety, this pattern will conflict for a long while with our newly learned positive behaviors. It is important to weaken the old habit and strengthen the new good habit. You can use the methods that people use in sports and music to change behavior.

- Practice the new behavior in isolation from any real situation that would make the old habit rise up. Practice methods for feeling safe. Practice at home long long before a test comes up.
- Practice new behaviors slowly, very slowly. Practice the thinking methods that lead to safe feelings very consciously and very slowly.
- Gradually introduce things that remind you of the real thing and practice doing the new behavior.

- Make lists of the new thinking patterns you've got and memorize them. When in a real test, and the old bad habit is running wild, use self-talk to recall the new thoughts to mind.

2. Avoid things that make the body feel tense

When people do certain physical things and take certain foods, they can arouse tension and anxiety. So we can help ourselves by helping our bodies be healthy, strong and relaxed. Many physical conditions can influence anxiety:

- Going without enough sleep
- Drinking too much caffeine
- Taking drugs that raise tension
- Tensing muscles
- Breathing rapidly in the upper chest

Such things can make our bodies feel tense, irritable and anxious. When possible, give yourself enough sleep for a few days before a major test, drink no more caffeine than you can tolerate, avoid drugs that leave you wired, consciously relax your body, and practice abdominal breathing. One person went for a massage before a major event.

3. Try to break the habit of using anxiety to motivate yourself

- Goals shape our behavior. People often create feelings in order to reach certain goals. When people use feelings of anxiety to motivate themselves to do their homework and try hard in school, they may actually turn on anxiety even when they are in safe situations. So we can help ourselves by stopping the practice of turning on anxiety.
- Sometimes we motivate ourselves positively by imagining a delightful result in the future and feeling drawn to achieve it. Other times we motivate ourselves negatively by imagining bad things that will happen if we don't act so that we feel anxious and aroused to act to fight off the danger. When people use negative motivation most of the time, they can even make themselves anxious about safe tests. They have learned to create worry in order to make themselves work, try, and face unpleasant events. If you live this way, then your old habit will fight your attempt to lessen test anxiety because your mind will fear that you will go passive and put things off and stop trying.
- One cure: Try positive motivation. Think of end results and their good features and you will be drawn to them. Take washing dishes: Don't think of your fear that if you leave them unwashed, they'll look ugly and you'll be afraid of others' criticism. Instead, think of how nice the kitchen will be with everything clean, orderly and ready for the next meal. Nice!

4. Try to see this test as different than other ones

When people interpret a new experience as another example of a familiar category, they think and feel about the new as if it were the old. Similarly, when we expect that an upcoming test will be the same as bad ones in our past, we react the same. However, if we can spot what's new and different about the new test, we have hope for escaping the trap of the old bad habits.

People who feel test anxiety often report that there are certain tests in certain subjects where they feel safe and don't worry. People good in math don't worry about it, but they may worry about their history exam. This fact leads to two-part advice:

- Remind yourself that this test is not the bad tests in the past that have scared you. It is different.
- Consciously look for what is new and more hopeful about your upcoming test or the test you are taking than the bad ones in the past. What are some possibilities?
- You may be taking a fairer test than before.
- You may be more mature, more knowledgeable, be more test-wise.
- You may know the subject better.
- You may have practiced and reviewed better.

What to do in a major anxiety attack during a test.

Suppose a test is beginning and the teacher has just passed out the tests and you look at the questions and you feel intensely anxious. You can hardly think. It's worse than normal worry. It's similar to the old saying, "I was so worried I couldn't remember my own name." What do you do? Here are several suggestions. Do any one or more.

- Put your pencil down, shut your eyes, and let the anxiety fully into your consciousness for 2 to 5 minutes. Stop fighting the worry. Notice feelings, thoughts, words, and mental imagery. It won't hurt you any more than it does already. Remember that your mind is trying to protect you by telling you that you are in danger and need to fight or flee. Acknowledge these messages. The feelings will peak and gradually lessen. As they lessen, you will gradually have some mental space to start thinking again.
- Breathe in deeply and hold your breath to the count of 10. Let your breath out. Do it again, perhaps 5 times or more. It will help calm you.
- Put a label on the feelings: They are symptoms of test anxiety, produced by your brain. They are not identical with you.
- Make an explanation for the feelings: They are caused by a combination of your past habits of worry firing off and your mind's interpretation that there is danger. These causes are not identical with you. There is more to you.
- Ask yourself if you can still do your job of answering the test questions even with the feelings. Usually you will have enough of your "self" and "will" left that you can choose to start the test.
- Start a healthy activity going. Since you are in the test, look at the test and hunt for questions where you know something and work on those questions first. As you work on those questions, you will activate your memory for more material, and as you get some answers right, your self-confidence will rise. People often find they gain memory for more and more material.

Prepare your methods in advance for dealing with test anxiety and practice them.

At this point, I, as the author of this pair of Study Tips on test anxiety, feel "worried" that you, the reader, are going to finish and never take steps to really learn even one of these methods. Sadly, most of us read self-help material, notice that lots of it makes sense and put it down. We think we have fixed our problem by reading the advice. No.

You need to prepare your mind so that when you are in a test, you can handle worry with at least one good technique. It is good to be so prepared with at least one well-learned and well-practiced technique that you can easily recall it and do it under pressure. How do you prepare?

- First, pick one technique. One.
- Read it over until you understand it.
- Then convert it into an imagined situation, goal, and actions that you will experience. Suppose you chose the method of seeing that the current test is new and different from past terrible ones. Then at home at leisure, imagine seeing the situation of the test room, teacher and students, the test. Feel your goal to feel safe. Then imagine thinking about the action, which would be thinking of the specific ways that this test is new, unique, and different from the past ones. And hopeful. Say to yourself, "This is my college test on X. It is not my terrible sixth grade math test with awful Mrs. Grundy. That's gone in the past."
- After practicing one, practice the others one by one.
- Finally, make a reminder list of techniques. Practice reciting the list until you could recall the techniques even when scared.

Study Tip #20 - THE SCIENCE BEHIND THE STUDY TIPS

Introduction:

It would be natural for you to wonder whether the Study Tips' suggestions are based on reality. They are. This Study Tip describes some findings and references. The other study tips use this scientific knowledge plus more. Read carefully because it is short and every word counts.

Sensory memory, working memory and long-term memory.

Our brains have memories that operate on different time scales.

- Our sensory memory holds images when we first see or hear something, and we can almost inspect the vivid raw images. It is short: 1-2 seconds for sight; up to 4 seconds for sounds; lengths for other senses are uncertain.
- Our working memory next holds chunks of information that we have paid attention to when in sensory memory. Working memory also holds memories we retrieve from long-term memory.
- Working memory is the focus of our consciousness. We can work with memories by making inferences from them and associating other ideas to them.
- Working memory images and information will fade in 15 to 20 seconds if we don't think about them, but we can make them stay longer if we do think about them.
- Working memory has a fairly small capacity: only 3-5 chunks of new information.
- Long-term memory holds our lifetime of learning and we are not conscious of its contents until we retrieve memories into working memory. The images and information in long-term memory vary in their strength. Some can last a lifetime; others fade quickly.
- **Implications:** We need to pay attention to information while it is in sensory and working memories so that we can think about it while it is vivid and associate it to what we already know and build memories. If we ignore new information, it fades leaving no lasting memory.

Declarative and procedural memory.

There are two fundamentally different kinds of memory, and they are stored differently in the brain and require different ways to learn.

- Declarative memory holds information that we can talk about (declare) and think over. Part of it handles facts, concepts, symbols, and images; we call it a **semantic memory**. Another part handles experiences we have gone through, which we call **episodic memory**.
- Procedural memory holds our memory for skills and habits; it remembers the steps we go through to accomplish a result. It applies to cognitive skills; examples are reading, talking, writing, multiplying numbers, and solving math problems. It also applies to physical skills; examples are walking, keyboarding, throwing balls, sewing, and driving. Many skills have both cognitive and procedural parts. For example, any sport has both a strategic thinking part and a physical part.
- We learn declarative knowledge much faster than procedural knowledge. We can learn some declarative knowledge in a few seconds. But it can take days, months and years of practice to build up cognitive and physical skills.
- We learn declarative knowledge by thinking it over and associating it to other things. In contrast, we actually practice procedures in order to build skill in doing them.
- **Implications:** We need to notice whether we are studying declarative knowledge or procedural knowledge.

Attention.

We pay attention to thoughts and external stimuli by focusing our consciousness on them, and they occupy our working memory. Speaking in a metaphor, our attention heats up the images that we focus on. When our attention leaves them, they cool down.

- We can partly choose what to pay attention to.
- We also have our attention captured by intense events in the external world and strong thoughts.
- The longer we fully focus our attention on a certain thing, the more likely we will be able to remember it. But if we quickly move our attention away from it to something else or if we switch our attention back and forth between two things, we will weaken memory.
- **Implicaions:** If we pay full attention to what we want to understand and learn, we will improve our mem-ory.

Intensity, associations, spaced study and recency of contact: four ways to influence learning.

- The longer and the more intensely we have studied a chunk of information, the stronger that chunk will be in long-term memory.
- The more we have associated a chunk of information to other chunks of information, the better we can remind ourselves of that chunk and recall it.
- The more we make separate contacts with material as opposed to long concentrated study, the less time it takes to learn.
- The more recently we have recalled and thought about a chunk of information, the more likely we can recall it now.

Mental representations.

- We can represent information in our minds in different ways using our senses: sight, sound, movement, touch, smell, taste, pleasure and pain, and more. Memory can be stored in each sense.
- We also have a memory for events that happen over time—both events we experience personally and events that we observe happening to other things. It's often called episodic memory.
- We can represent information in abstract ideas, concepts, symbols, words, stories, time sequences, and lists. Memory can be stored in each of these ways.
- The more ways we represent a chunk of information and the more we associate the representations, the more we strengthen our memory.
- There are situations where it is helpful that we match the reality that we are learning about with the representations we use. A match will strengthen memory. If visual images are important to learn something, then even if our strength is in verbal knowledge, we should make associations to the visual information.
- There are other situations where it is more helpful for us to use the representations that we have most skill in using. For example, if an athlete who is skilled in thinking kinesthetically—movement, force, pressure—deals with a visual or verbal subject that can be imagined kinesthetically, it will be helpful to make up little stories about the material that involve hands, arms, legs and body movement.
- **Implication:** When taking in new information, if we make ourselves aware both of how it was represented and what additional representations we can translate it into, we can make strong associations.

Chunks are the basic units of information that we perceive and learn. They are the atoms of thought.

- A chunk in declarative memory has about 3 to 5 elements associated together. Once learned, we can associate several chunks into a larger chunk, and those larger chunks into even larger ones.
- Each step in a procedure is learned as a 3-element chunk: the current situation, the current goal, and the current action. We build up skills by doing several chunks in sequence, by building in decision and choice chunks, by practicing so that we do the chunks more quickly and accurately.
- **Implication:** We can speed up learning by organizing information into small chunks and then by grouping several chunks together into larger units.
- **Implication:** The more that we choose to make the chunks match what is useful in the subject, the better our memories and skills will be.

Meaningfulness.

When we find or make new information meaningful, we can learn it more quickly than less meaningful information.

- People often find the following things low in meaning: new symbols, new words, foreign words, numbers, proper names, facts that make no sense.
- **Implication:** When we notice that material is low in meaningfulness to us, we should plan to use special study methods and take more time.

Interference, misconceptions and existing habits.

- Interference occurs when we study a lot of somewhat similar material close in time. Each set of new knowledge interferes with our accuracy in remembering the other set. It lowers our memory.
- When we already think we know something but it is wrong, our old ideas will interfere with learning the correct ideas. We will take longer and make more mistakes in learning. For example, physics teachers report troubles teaching Newton's laws of force and motion because students natural ideas are contrary.
- When we are trying to learn a new skill but have poor existing habits in that area, our old habits will interfere with learning good new habits. Music teachers find that students who have taught themselves to play an instrument report need a long time to undo their bad habits. The teachers almost prefer to teach students who have no experience with the instrument.
- **Implication:** We can reduce interference by making distinctions and practicing more.

Brain's speed of operating.

Our brains take a certain period of time to move from seeing a word or an object to recalling what it is. It can take about 0.3 to 0.6 of a second from the time we see a word to the time we think of its meaning. It takes another part of a second to classify a meaning.

- If we read faster than we can think of words' meanings, we will damage our understanding of what we are reading. People often read too fast.
- If we think faster than we can notice our mind's associations, we will think poorly.
- **Implication:** We need to choose a speed of reading and thinking that matches the time than it takes meanings to come to mind.
- **Implication:** We can build in pauses after reading chunks of information to give time for associations to form.

References:

John R. Anderson has two good books that explain a lot about learning and memory: *Cognitive Psychology and Its Implications* (now in its 6th edition) and *Learning and Memory: An Integrated Approach*.

Study Tip #21 - RESOURCES AND OBSTACLES TO LEARNING

People must learn very diverse kinds of information and skills. Not only do topics differ greatly but the very structure of knowledge can differ. Our learning goals can vary and so can the degree of perfection required. To match this variety of learning tasks, you will find it helpful to have a broad checklist of things to keep in mind when you study. Our minds give us several major resources we can use, and both our minds and reality put ob-stacles in our way.

Our Minds' Resources:

As humans we come with several major resources that help us learn. Oddly, it is pos-sible to ignore these mental resources and still learn, but to learn more slowly. If you do use these resources wisely, you can learn more and save time.

Attention. When we pay attention, we intensify our mind's ability to understand and remember. We come with the ability to partly control what we pay attention to. When we are distracted, we can pull our attention back to what we want to focus on. Implication: Pay attention! Don't let distractions last very long.

Goals. When we want to get a certain result, our mind will help us. We come with the ability to set goals and work for them. Implication: Choose useful learning goals. Don't read or listen passively.

Self-tests. When we test our degree of learning and find out whether we are reaching our goal, we can know when we've learned enough. Implication: Test yourself.

Our three memories: We come with a sensory memory (lasts 2 to 4 seconds), a working memory (lasts 15 to 20 seconds), and a long-term memory (lasts a long time). Implication: Work to exploit these memories' powers.

Recent contact with information: When we have recently seen, heard or thought about a certain bit of information, it gains freshness and is easy to recall for awhile. Implication: Review shortly before a test or a skill performance.

Associations. Our minds are always associating from idea to idea. When we focus on some experience or idea, our mind retrieves into working memory the things we have associated with it. It happens partly by following our goals and by what is already a learned association. Implication: Intentionally create associations and stimulate associations in order to recall memories.

Knowledge and skill memories: Our minds store some learning as knowledge of facts, experiences, and ideas. We store other learning as knowledge of how to do procedures quickly and accurately or to build skill in an action. Implication: Notice whether your learning goal is to learn knowledge or to build a skill; you will study them differently. Learn knowledge by elaborating on it and testing yourself and expect to learn it in a few tries. In contrast, learn a skill by practicing it in small bits and comparing your results to the ideal. Practice again and again over many days.

Different ways of representing knowledge. Our minds also let us store knowledge visually, auditorily, in terms of feelings, through touch, through movement. We also have an episodic memory. We can also represent information in terms of stories and personal experiences and abstract concepts. Implication: Learn knowledge several ways and associate them together to give yourself several memories of the same event. When you read, translate the words into other representations you can imagine. And when you take information in through your senses, talk to yourself about it to put it into words.

Many ways to associate. Be aware that you can make associations within each way of representing the world. You can use multiple representations for a subject; the most common are visual and verbal memories, and there are many more. You can also consciously make associations between two or more representations. Again it is common to associate visual to verbal memories but there are many other ways. The more associations one makes, the more ways one has to retrieve knowledge later.

Obstacles to learning:

There are several major obstacles that can slow down our learning or can make us learn mistakes. If you can spot these obstacles ahead of time, you can work around them and still learn.

Memory fades. Sensory, working and long-term memories all fade over time. When reading long passages, our memories for the first taught facts and concepts may have faded by the time we get to later passages that use them again, and we cannot recall them. Implication: To successfully learn and remember material, we must strengthen new information quickly and keep renewing it.

Interference occurs. When we try to learn several things close together, our minds will confuse many of them and weaken the accuracy of our memories. Implication: We need to use techniques that overcome interference.

Distractions lower attention. When we try to focus on something, other noises and sights can capture our attention. Moreover, inner feelings and thoughts can also distract us. When we are trying to do two or more things at once, our attention keeps switching back and forth and weakens our focus on any one of them. Implication: Fight distractions.

Too fast working speeds prevent learning. When we feel we must rush to get a learning task done, we can outrun our mind's limited speed of taking in information, making associations to it, and making impressions stronger. Implication: Make your working speed adapt to your mind's natural speed of working.

Complex material hinders learning. When a book has to explain a topic with many parts that lack an obvious pattern, it is hard to understand and hard to remember. Implication: Recognize complexity and study to make it understandable.

Large volumes of material hinder learning. When there is a lot of material to remember and too little time to learn it, we can fail to reach our learning goals. Similarly, when we are trying to develop skills doing procedures with many parts to them, we may not have enough time to practice and will fail to build up skills. Implica-tions: Recognize heavy demands and choose the most important to study.

Meaningless material hinders learning. When we study new information and cannot find any natural meaning to it, our memory for it will grow unusually slowly. Examples of relatively meaningless material are new symbols,

numbers and dates, new technical terms, people's names, and arbitrary facts. Implication: When you notice that material is meaningless to you, study it by using mnemonics, by doing extra repetitions with flash-cards, or by finding ways to make it meaningful.
Misconceptions. When we already have learned confused and partly mistaken information about a topic, these misconceptions may keep us from learning the new correct information. Implication: Be aware when your mental model does not match what the author is teaching and do extra studying to cancel the old and strengthen the new. only When we have already learned a skill in an area where we are practicing new skills, the old skill will keep intruding and interfere. Music teachers say it's easier to teach someone an instrument if they are brand new to it than if they know a little and have bad habits. Implication: Be aware of situations where an old skill must be unlearned and a new one substituted and know that you will need extra time. Be merciful to yourself.
Bad habits of reading and studying tend to persist. When you want to improve your reading and practice and study habits, your old habits will tend to persist. A common bad reading habit is to read passively, just letting the words and meanings slide by. Implication: Be prepared to need time to practice better study habits.

More Implications for Studying:

- When you are getting ready to read your textbook, think of your learning goals before you start. Use your teacher's goals and think of the ways test questions will be asked. Define your specific subgoals as you begin a reading or study session.
- Use different goals in different study situations.
    - On your first time reading a chapter, try to understand the material.
    - On the second time, try to find and gather together the things you need to memorize. Also try to notice associations between them.
    - Look for things that describe skills you must learn. Look for methods to solve problems and accomplish thinking tasks. When you set your learning goals, set goals to build both accuracy and speed. When you are a beginner, set low goals for a practice session. As you get better, set higher goals.
- Our brains' limited working speeds have many implications. Pay attention to the actual meanings of the words. Also pay attention to the overall meanings of sentences and paragraphs. The limits to working speed mean you will read slowly enough to give your mind time to pop meanings into your mind. These limits also mean that you will pause a second at the end of complex sentences and paragraphs to digest the overall meanings.
- When you test yourself, use associations by asking questions that are naturally associated with information you want to learn. Don't just look at a fact and repeat it. Instead, ask a question that will be answered by recalling the fact.
- Use associations by thinking over the new material and letting your mind go from one idea to a fact and to another image and so on, so that you link them together. Go back and forth several times.
- Space your learning by making multiple contacts with the reading. Do reviews after a few hours or the next day. Do previews of upcoming material. Space your skill learning by practicing over many days.

Study Tip #22 - SPEED AND TIMING TRICKS TO IMPROVE LEARNING

Introduction:

All activities take time. We often forget that it takes our brains time to move from one thought to another. If we try to learn faster than our brains can process information, we will run into trouble. If we go about as fast as our brain can go, we will learn more the first time, and we can eliminate wasting time for extra reviewing.

Sensory memory fade time:

When we look at something and shut our eyes and think about what we saw, we see a large-scale vivid image that lasts for 1 to 3 seconds. It fades rapidly. The next thing we see overlays the first image. (We have similar sensory memories for hearing and the other senses.) You may find it helpful to look at something now, shut your eyes, and notice these vivid memories.

- If we want to use sensory memories to learn something, we must act quickly.

- When you look away, shut your eyes immediately and focus your attention on the part of the visual image you want to notice. By doing that, you will move some memory into your working memory and you can process it longer.

Working memory fade time:

Working memory holds information we are thinking about consciously, both recent material from the world and from our long-term memory. While information is in working memory, we experience it as clear and easy to think about. If it fades before we learn it, we may never be able to retrieve it. How long does it last before fading? The traditional figure is 15 to 20 seconds.

- When you want to remember something, pay attention to it and it will stay available to you. If you pay attention to other ideas, it will fade.
- When you want to associate ideas to something in order to build a memory for it, do it within 15 to 20 seconds of taking it in.
- If you are testing yourself as to whether you have really learned something, do not test yourself right after looking at it or hearing it because it will still be in your working memory and fresh.
- Test yourself after letting it fade and after thinking of something else for a few seconds. Then ask your question and see if you can pull the answer from your long-term memory.

Association time:

Much of our learning occurs by associating a new stimulus to a familiar stimulus. We see a new word and then see that it means a certain thing that we are familiar with. We do it again several times: see new and see familiar. Then we are able to see the new word and recall what it means. How soon is it best that we follow the new word with the meaning? The answer from animal experiments is a fast 0.5 seconds, one-half a second.

- When using flash cards to learn, look at the new word and quickly turn it over to check the definition. Do not delay.
- When learning verbal information, take advantage of visual representations because they hold lots of information in the same picture. When you can translate a few sentences into a picture, your mind can see many things at nearly the same time.
- When you have to learn things verbally and the time takes a few seconds, be aware that you will need to practice longer.
- When you have to learn things by reading or listening and there is a time gap between the new and the familiar, hold the first one in your working memory by paying attention to it until the second one appears. Then your mind will treat the two as occurring close together.

Learning facts:

How long does it take to learn factual information?

- People can learn facts in 10 seconds or less.
- In contrast to meaningless facts, when facts are meaningful to people and they can put them into mental frameworks of information, then learning happens faster. Example: If you know football teams and rules and someone tells you a score, you will learn it fast.
- If facts are meaningless, learning goes much slower and takes much repetition. Examples: Learning symbols, new and foreign words, people's names, facts that are just there with no reason, numbers, dates. Expect to take need longer to learn meaningless information.

Learning skills:

How long does it take to learn a thinking skill or a physical skill? How long to build up your speed and accuracy?

- If we are judging the learning of a thinking skill by getting just minimally satisfactory speed and accuracy, one psychologist found it could take about 40 repetitions to learn.

- If we are judging any skill learning by true expertise, it can take months and years of practice.
- Plan to practice new thinking skills by doing problems many times over many days. If you learn skills slowly, know that slowness is normal.

Spaced learning vs. massed learning:

When you study material or practice a new skill you can either space it in many short sessions or a few long sessions of massed practice. Assuming you studied the same amount of time in total, which pattern of studying works best? Spaced learning.

- Space out your learning sessions so that you make multiple contacts with the same content a number of times. One research study used 2 sessions a day over 4 days.
- Use massed learning only for emergencies when close to a test.

Recency of contact:

- Our memory for information is better if we have recently used it. The more recently, the better.
- Plan to review important material right before a test, if you can. Focus on the hardest material.

Limiting the damage of interference:

When people study a lot of information in one study session, interference gets worse when the items are fairly similar. The various bits can interfere with remembering each other. Examples: Reading about several English kings and their wars, learning many new similar concepts (kinds of mushrooms, kinds of social norms).

- Break up your study of topics with similar information by switching to another topic that is quite different. Read history, then turn to math.
- Choose a time of day when you can take a nap or sleep for the night right after studying. Do this trick when studying your hardest material.
- Explicitly notice similar concepts and test yourself on them until you can distinguish them.

Reading for meaning:

When we read, our brain needs a little bit of time to see a word, look up the meaning, and send the meaning to our working memory so that we are conscious of it. How long does one word take? It takes 0.3 – 0.6 seconds.

- When we read familiar words and ideas, we can get the meanings faster. But when we read new material, our brain needs longer to find the meanings and send them to us.
- We can have good days and bad days. Our mental speed will vary by what we've eaten and drunk, how much we've slept, how well or ill we are, and even by how old we are.
- When you read, pay attention to whether you are getting the meaning of words and phrases.
- If you are reading too fast, slow down until meanings come more clearly.
- When you reach the end of sentences, pause a little longer so that your brain can put together the whole meaning of the sentence.

Blank time:

When we read or think about information in little units and take a definite pause after a unit before we process the next unit, our understanding and memory will improve. How long should the pause be? One researcher found that blank times of one second worked best to help people learn a list of words. I don't know of other research on these lines. I expect that when reading a textbook, slightly longer pauses of 2-5 seconds after a paragraph would be helpful. This is a guess.

- When you want to seriously learn from a book, read in little cycles. Read and pause, read and pause.

Retrieval time of memories from long-term memory:

When you need to recall a concept, time passes between the time you "ask yourself" for the information and the time it pops up. When people recall familiar information, it can come to mind in a fraction of a second. We are so used to having our minds work this fast that it fools us when we don't recall something quickly and we give up too soon. But people searching for information can retrieve it over periods of several minutes to days.

- To retrieve an item, think about anything you know that is associated to the forgotten item. Focus attention on the associated items because that helps activate the buried memories. Allow time. Watch your thoughts as they lead to the memory you want.
- When recalling information on a test when time is short, spend a minute or so associating. Then move on to other questions. After a few minutes, check to see if your mind has returned the answer.

Study Tip #23 - SCIENCE: READING A TEXT CHAPTER FOR THE FIRST TIME

Outline:

- The problems in studying science that study methods must deal with.
- The basics: build understanding, associations and firmness.
- On your first reading of a chapter, work to understand it.
- Make notes on forgettable concepts and facts that will be used later.
- After reading sections, do little mental reviews and self-tests.
- Take advantage of making easy associations.

The problems in studying science that study methods must deal with.

Although most students know that science courses contain a lot of new material, they are not aware of other traits of science that make it hard to understand and hard to create useful associations. Here are a few traits:

- Science courses introduce many facts and ideas that are intrinsically hard for the human mind to remember because they are not very meaningful. Examples include technical vocabulary, numbers, symbols, formulas, facts that come with no context, and names. Students may read a new word on one page and understand it while it is fresh in their memory, but when they meet it after a couple pages and several minutes have passed, they may have forgotten it and be unable to understand both it and the sentence and paragraph it is written in. Certainly, students encounter many familiar ideas in their science courses, but the amount of information that is meaningful at first glance is often low in science courses.
- Scientific ideas can be complex, contain multiple parts, spell out chains of linked ideas, and state exceptions to generalizations. Complex ideas can be both hard to understand and hard to remember. Complexity requires paying careful attention and making many distinctions.
- Science learning tasks often require learning skills by practicing; skills cannot simply be memorized. Usually, students find they need to read a science text and study their notes more than once. How can students learn accurately during their first reading of text chapter and build memory as fast as possible? How many study activities should be crammed into their first reading? What activities waste time? What activities are useful? I think the answer is to keep it simple on your first reading. Save the formal study methods for your second and later contacts with the text. What this Study Tip on studying science contains is advice on how to understand a science text more quickly and how to make associations even during your first reading of a chapter. Later study tips on science will discuss how to reread and study science texts and lecture notes.

The basics: build understanding, associations and firmness.

Many of the other Study Tips in this series stress that to learn knowledge is to get a clear understanding of it, to build associations to it, and to make firm the understanding and the associations. I will assume that you are familiar with basic ways to learn and build memory: the roles of setting specific learning goals and paying attention, the distinction between learning explict knowledge versus building up skill in doing procedures, the many ways to make

associations to new knowledge, how to practice and give yourself useful self-tests, and how to retrieve information from memory. If you need a refresher, check the other study tips. This study tip will focus on what works well for science studying.

On your first reading of chapter, work to understand it.

Set your goal to understand what the writer is saying. The reason is that complex writing in science makes understanding harder to get, and understanding ideas first is a prerequisite for learning and using information. Be aware that when you read, retrieve the meanings of words, and figure out the meanings of phrases and sentences, you are building useful associations already. You will build even higher-levels of associations when you read and study passages later.
Try to understand the following things during the first reading:

- Words. Be very careful to understand words. Each blurred word blurs an idea and spreads its damage to any sentences that use it.
- Sentences. Each sentence expresses basic relationships among ideas expressed in words and phrases. If you cannot understand certain sentences, you will miss parts of descriptions, explanations, and scientific reasoning.
- Paragraphs and higher levels of structure. Often it takes a lot of writing for a scientist to fully describe and explain natural phenomena, and it is useful to understand as much of these larger units as you can.

I recommend that you mostly read to understand the first time. Why? You will probably find you lack the "mental space" to add other learning tasks because it takes all your mental energy to work out what the author is saying. You won't be able to detach your attention from your reading to classify parts of the material or to relate one part to the overall structure. If you did, you'd forget what you were reading about. If you try to use meth-ods like SQ3R (survey, question, read, recite, review) on your first reading, the sheer amount of time it takes will interfere with your ability to understand the text. I recommend you read carefully with attention and work to understand the meaning of what the author is saying. When you don't understand, use various methods de-scribed in Study Tip #2 to try to get understanding and/or mark the passage with a big question mark to remind yourself to go back later and try again.

Make notes on forgettable concepts and facts that will be used later.

If you make a helpful list of critical new vocabulary and brief definitions, you can quickly review the meanings of later sentences using those words. As you read the chapter, write a list of words on a paper kept right beside you as you read. You can also put on your list the page where the definition occurs. Such a list made on the fly as you read lessens the forgetting problems caused by lots of new vocabulary. Since so much understanding comes in science via words, a little word list lets you meet the word later, recognize that you have forgotten it, and quickly look over to your list and remind yourself of it.

Certain facts in science can be critical to your understanding, and, sadly, they can be forgettable. A little list of such facts made on the fly as you read early parts of a chapter can be used to clarify later parts of a chapter. If it takes too long to write the fact down, just name the fact ("the table of planet Jupiter's properties") and the page it is given.

What if you cannot guess in advance whether a certain word or fact will be useful later? That happens all the time. Deal with it the very first time you run into the word or fact again and cannot recall its meaning. Look back, find the page, and this time jot down the definition or the page it occurs on, and read on. It will slow you down if you read passages using words defined earlier that you have forgotten and just read on. Your lack of understanding will make you inaccurate and prevent you from forming natural associations.

After reading sections, do little mental reviews and self-tests.

Imagine you are reading a few paragraphs on a topic and you come to the end of a section. You stop, look away and think, "I wonder how well I can say what this passage said." Then you try to recall as much as possible. When done, you quickly scan the passage and notice what you got right, what you got wrong, and what you omitted completely (the most common happening). If you wish, you can redo your mental recitation and put in the corrections.

Such little reviews can be done during your first reading and they will boost memory. They are never enough to prepare fully for an exam, but they can cut down the study time you need because the reviews are done while the information is fresh in your mind. They boost your accuracy. And they also build associations through your episodic memory, i.e. your memory for things that occurred in a sequence. Episodic memory is a fundamental property of human memory, and this method takes advantage of it.

Take advantage of making easy associations.

When the textbook presents easy associations, take advantage of them during your first reading at the time they are fresh in your working memory. Four examples of easy associations found in science texts are these:

- Some text about a subject accompanied by a graphic—a picture, diagram, or chart.
- A familiar analogy accompanied by the technical explanation.
- A formal description of a subject followed by a concrete example, story, or evidence.
- A verbal statement of a relationship matched with a math formula to express it.

Science texts will help you make easy associations because they constantly pair new information with one or more additional ways of saying it or representing it. Take advantage of them by pausing in your reading to look back and forth from one of the pair to the other and back again. In your mind notice how each of the pair translates into the other representation. For example, notice how words translate into the parts of a diagram; notice how the elements of an analogy map onto the parts of the technical explanation; notice how the parts of a formal description are represented in an example, story or evidence; and notice how the symbols in the formula and the words match each other. By doing this back and forth translation you will literally create associations on the spot.

Suppose you don't pause and associate but just read on through. What would happen? First, you would omit making several associations because you would not notice how the details of each representation map onto each other, and second, you would miss a chance to firm up any associations you made by repeating on the spot.

Several tips for making easy asssociations:

- When translating between words and images, start by asking questions. For example, you might ask yourself, "How does this verbal idea match a visual idea?" Then answer the question. If you start with a part of the image, ask yourself, "How does this part of the image translate into words?" You can use other questions. "I wonder what that phrase looks like in the image?" "I wonder what words would express this picture?" Similar questions can be developed for analogies and examples. The purpose of asking a question is to make the question something in your mind to associate with and then link an answer to it. Later in a test or in real life, when a similar question occurs you are more likely to be able to recall that information.
- Use your fingers to mark each of the two parts that are separate but related. The purpose is to speed up your ability to look back and forth at each of them; seeing one right after the other makes it easier to build firm associations.
- When reading definitions of concepts and examples of them, pause in your reading to make time to discriminate and generalize the definitions while the ideas are still available in your working memory. To discriminate among concepts means that you think about the differences between related but dif-ferent concepts. To generalize a concept means that you think about a wide range of examples that the concept applies to. If you merely read on, your memory for the definitions will fade and you may lose the ability to make sharp discriminations and generalizations.
- When you are studying a section on how to solve problems, do some problems right away in the same study session, before your memory fades. By promptly doing problems after reading about them, you make associations. Don't delay overnight or your faded memory will often create the need to restudy the material in order to do problems.

Conclusion

Notice that this study tip on doing your first reading of science text chapter deals mostly with getting understand-ing. It takes advantage of making easy associations. But it omits making associations firm. When you read and study the chapter again in different ways, you will build many more associations, see more relationships among the parts of the chapter, and make associations much firmer.

Study Tip #24 - SCIENCE: STUDYING A TEXT CHAPTER

Outline:

- Making associations firm and useful
- The usefulness of studying after reading
- Definitions of concepts—six aspects of them
- Goals of science—clues to topics for association
- Descriptions
- Explanations
- Predictions
- Uses of knowledge
- Scientific reasoning and arguments
- Conclusions and implications
- Two tips to use when study time is limited

Making associations firm and useful

The basic goals of study are to understand information accurately, to make associations between the new knowledge and your own knowledge, and to make the new associations firm and durable. As you read a science chap-ter thoughtfully the first time, you will naturally make some associations, both to your own past knowledge and to the many new facts and ideas and images in the chapter. These associations are useful but incomplete. You should not expect that your natural associations will be enough to master a chapter because he chances are that they will be somewhat random. They may not match your instructor's model of the field, nor the way he or she approaches writing test questions. How can you study so that you make associations that match the way scientists think about the field? How can you make associations that are important to science?

This Study Tip will explain how to classify the content of the chapter into important categories. Then you can easily collect items that belong together. You might make marginal notes on these categories or you might jot down brief lists of items. Once that is done you will be able to link together parts of the chapter that were previously separated and start learning them in relationship to one another. The next Study Tip will discuss ways to build memory for the chapter.

The usefulness of studying after reading

Some people resist using formal study and memory methods. One reason is that when they read and understand a text chapter, they feel confident that they understand. But how long will their memory last afterwards? Not long, especially if the material has many topics and findings, new vocabulary or math. The natural fading of new memories leads to forgetting what was read, and the interference between similar items of knowledge will leads to confusion of the findings. Students who do not study may not be able to answer questions that involve listing topics and findings or that require noticing relationships among the parts to form larger wholes.

Our brains need short time gaps between thinking of two or more items in order to associate them together. How short? Half a second is the best, unless you can put one item in your working memory and then read the other item and think back and forth between them. Reading does not meet this requirement because it is linear and takes time. When a science text gives a definition or description or explanation or some other kind of information, the text can take several pages and several minutes to cover all the parts. By the time you read later parts and understand them, your memories may fade for the earlier ones. Moreover, unless the author's writing is very clear, it may not occur to you that the later items should be associated to the earlier ones. That is why it is useful to review after reading and to bring together related information that has been separated. Your explicit studying will help you collect things that belong together in ways that scientists think. After you collect them you can build associations and memory more easily.

Definitions of concepts—six aspects of them

Collect six aspects of concepts that writers will often give to clarify new words. Since this information is explained in more detail in Study Tip #25, I will just list the items. A *concept* can be thought of as an idea in our minds. The *word* you learn is the name of the concept.

- The verbal *definition*
- A *visual image* used as an example
- One or more *positive examples* of the concept
- One or more *negative examples*
- A *prototype example*
- A *unit of measurement*

Many test questions will involve various aspects of definitions of concepts. Instructors will check whether you can discriminate among concepts, generalize to far-out examples, and know how to measure things.

Ways to study: After you gather the various aspects of a concept, go in two's—pick 2 aspects and look back and forth while telling yourself that each in part of the concept, then pick 2 more, and 2 more. Use your judgment as to what is important. Your goal is to think of one asspect and have it remind you of the others.

Goals of science—clues to topics for association

A short summary of the goals of science goes this way: *Scientists work to create true descriptions, explanations and predictions of real phenomena and to use this knowledge for human benefit. They also work to support their ideas with solid evidence and reasoning.*
If you get used to noticing material in a chapter that fits into these goals, you will be understanding the bigger framework of science and how new information fits into it. One comment: both explanations and predictions will often come in cause-and-effect statements. When you start with a result and inquire into its causes, you are asking for an explanation. But when you start with a phenomenon and ask about what results might occur, you are asking for a prediction.

Descriptions

Descriptions in science differ from definitions. If you *describe* the orbital period of Mars, you give a specific number—1.9 Earth years. But if you *define* the concept of *orbital period* you say that it is the length of time an object in the solar system takes to go around the sun or around its planet.
Collect and gather together descriptions of phenomena. Sometimes you will find all of a description of an object or event in one section in a book; other times it will be scattered and you will need to bring the parts together. Sometimes science writers give the descriptions in ordinary prose and then summarize them in a large chart. For example, when astronomers describe the properties of our solar system's planets, they often make large tables of the planets' mass, orbital size and speed, atmosphere, etc.

One major kind of description talks about the attributes and properties of objects and events. Some descriptions are specific to just one thing or event; others summarize the general properties of a whole category of similar objects and events. Many scientific descriptions require numbers. Another major kind of description shows how whole things can be broken into parts, how smaller objects can be linked to others to make larger wholes, and what things are made of. Descriptions of events describe their patterns and their sequence in time. One can also describe things in terms of their environment—their frequency and their distribution.

Ways to study descriptions:

- You can use any tables that authors give to summarize various descriptions. They are very useful.
- You can use brute force methods that involve flash cards, self-tests, cumulative addition to a set and spaced reviews.

- You can use the question "Why does this fact make sense?" about each fact and try to answer it. Simply asking and answering such a question often creates such strong associations that you won't need to add brute force memorization. If you use the "make sense" question, you will save study time.
- You may want to think of objects (planets, certain chemical enzymes, the life style of bird species) as having a kind of personality and pretend you are that planet person or enzyme person or bird person going about its business. Making such a jump in imagination to personality and empathy taps parts of your memory that are very strong.
- You may want to create little stories about objects with characters and events that come out of the descriptions. "I am the planet Jupiter. I'm the biggest kid on the block, with lots of rings, a deep stinky atmosphere and a big red spot." Then go into whatever traits of the description you want to make meaningful and to integrate with associations. Review it at spaced intervals to firm it up.

Explanations

An explanation tells some of the factors that influence why an event took the course it did or why a phenomenon has occurred. For example, a section in an astronomy book might ask why the sky looks blue. It is asking for the explanation of the blueness. It will explain that blue light, which is about 400 nm in wavelength, goes through the atmosphere in which the air molecules are about the same size and, therefore, scatter the light. But the red light, about 700 nm, does not scatter as well. So we see more blue.

Explanations are sometimes given in terms of basic physics and chemistry. Other times, they occur as a chain of several events. Often both basic laws and chains of events are combined into one explanation. Scientists do not claim that all explanations are certain, merely probable. And since many events and things combine to influence events, it is somewhat artificial to cite one cause, and scientists know it.

Ways to study explanations:

- Organize a series of causes and effects into a chain (one cause, one effect, another effect, etc.) or a fan (single causes lead to multiple effects), as appropriate. Then study the series of phenomena in sequence. Then using look-away methods for self-testing, try to recall the series.
- When one phenomenon has multiple causes, ask yourself, "Why does this phenomenon occur this way?" and give your explanation. Note exceptions.
- Ask yourself, "Why does this cause-effect series make sense?" and try to give an answer in terms of the underlying physical-chemical causes. If you can't do that but notice a silly pattern or notice an association that's personal, use that as mnemonic for your answer.
- Use spaced study to firm up your memory.

Predictions

A prediction goes forward in time from a certain phenomenon and tells what is likely to happen next. Scientists trace out the consequences of events. For example, after a storm on the sun, particles are ejected and interact with the Earth's magnetosphere leading to the aurora borealis, the Northern Lights. Thus, an observer of the sun who spots a solar flare can predict a coming episode of Northern Lights.

Ways to study predictions:

- As in studying explanations, organize a series of causes and effects into a chain or a fan and try to recall the series.
- When one phenomenon gives rise to several effects, ask yourself, "What are the results of this phenomenon?" and state the effects. Note conditions that influence effects. Note exceptions.
- Ask yourself, "Why does this cause-effect series make sense?" and try to give an answer in terms of the underlying physical-chemical causes. If you can't do that but notice a silly pattern or notice an association that's personal, use that as mnemonic for your answer.
- Use spaced study to firm up your memory.

Uses of knowledge

Most science texts have sections that discuss how scientific descriptions, explanations and predictions can be used for human benefit. These topics can be highly interesting.

Ways to study uses of knowledge:

- Use the question "Why does this use or application of knowledge make sense?" and give an answer.
- Think about real-world problems or values that you have experienced or heard about in the news, and then think for a minute how the text's suggested application fits with the example you are thinking of. Then when asked on a test about uses and applications you may recall the examples you thought over.

Scientific reasoning and arguments

Scientific reasoning describes evidence and develops logical arguments that justify and support scientists' claims about nature. There is always a first time when scientists think they have discovered a new phenomenon and then try to describe it, explain its causes, predict its results, and discuss its uses for human benefit. Such claims are often controversial and so scientists need to justify them with reasoning. For example, when Darwin proposed his explanation for the origin of plant and animal species and said it was due to natural selection, he reported a massive amount of observations that were consistent with natural selection and inconsistent with other explanations. When the famous astronomers claimed that they had discovered such things as the canals on Mars (!), the expansion of the universe, the mysterious dark matter and more mysterious dark energy, they wrote long articles giving their reasoning, observations, and interpretations.

There are at least three reasons why you will often see scientific reasoning in introductory textbooks: (1) To describe the history of the field; (2) to teach students how to reason about scientific evidence; and (3) to deal directly with the fact that some theories may not yet be fully confirmed.

Ways to study scientific reasoning and arguments:

- Such reasoning will have many premises, inferences and conclusions. Premises are assumptions. Infer-ences are the implications that follow from the premises. Conclusions will be inferred results that follow from the premises and inferences. The ultimate conclusion will claim that the scientist's claim about a principle or fact is supported. Pick out the reasoning you can find and see if it is consistent and complete. Start by picking out the parts (premises, inferences from premises, and conclusions) and then check their connections.
- When you read an introductory science text, most commonly you will find evidence reported and often only summarized briefly. When an issue is controversial, you will see evidence and reasoning given on both sides and sometimes also see the textbook writer's own stand. Such cases are hard to analyze and you may have to use ordinary methods to understand and memorize them, if necessary.
- Ask yourself about passages with reasoning and arguments, "Why does this make sense?" It will help your memory.
- Also when a course stresses the learning of scientific reasoning, ask yourself if you can see flaws in the logic. Such a question will help you search for holes in an argument, find them, and remember them.

Conclusions and implications

Since the elements of the goals of science are present in science texts, you can use them on your second reading to pull together and organize the chapter.

- On your second reading, locate the six aspects of definitions; the descriptions of objects of events; the explanations for phenomena; the predicted results of phenomena; the uses of knowledge; and the scientific reasoning and arguments on topics. In many chapters you will find these elements scattered through the chapter.
- Every time you notice that a fact or statement in a chapter is an example of one of these goals of science, you will create a new association and firm up old ones. If after noticing it you go on and think about it, you will make

even more associations. Your memory for the material will improve. And you will read the chapter in a different way, not word for word, but by looking for the aspects of definitions and the goals of science.

- You have choices as to how to organize things. You might take notes. Or you might mark little codes in the margin. For anything bearing on definitions, you might put a letter D. For explanations, put a letter E. For predictions, put a letter P. For uses of knowledge, put a letter U. For scientific arguments, put a letter A.
- When asked a question in a test, you can notice if the question asks about the definition or one of the goals of science and search your memory that way. And if you had studied by noticing definitions, descriptions, explanations, etc., then your mind may associate to the answer.

Two tips to use when your study time is limited

- The first suggestion skips collecting the various kinds of statements. You will read once and then go right to the task of reviewing and self-testing.
    - Read the chapter for understanding. Pay close attention. Avoid reading too fast.
    - Review. Start by scanning to find a clear topic or scientifically significant statement, and then before you look at the details ask a question about it. Look away and try to give an answer, then look back and find the text's information, look away again and give the answer better. Then move on to the next topic.

Why it works: Self-tests can lead to making mistakes and they arouse helpful emotion and curiosity as to what the right answer is. By asking questions you create a retrieval cue, and by trying to give an answer you work towards the goal of retrieving information from memory. When you get it right, you have made the memory firmer. When you get it wrong and look for the answer and try again, you create an emotionally charged memory because of the sting your mistake has made and the satisfaction your corrected answer gives you.

- The second suggestion has you search for just one kind of scientific statement.
- Let's assume you will naturally notice the words and definitions and learn what you can. What else should you study when time is short? You may know your *instructor's goals*. Hunt for that material. Classify it as definitions, descriptions, cause-and-effect knowledge, uses of knowledge, scientific arguments and reasoning, or building skill in solving problems. Then try to learn it.

If you don't know your instructor's goals, then perhaps the most important kind of statements in science texts are the *cause-and-effect statements*. I suggest you search the chapter for them, mark them with a little C (for cause) in the margin, and then review by going directly to them and try to understand them, relate them, look away and practice recalling them.

Why it works: As you find either what the instructor wants or the cause-and-effect statements, that material will help you organize the chapter's parts together and see the larger patterns. Your searching will also lead you to classify the material again, and this kind of mental processing builds memory. Of course, since your time is limited and you are limiting your studying, you will miss other major things to build associations for. But at least this quick review will almost guarantee that you find some central important things.

Study Tip #25 - SCIENCE: DEALING WITH VOCABULARY, SYMBOLS AND MATH

Outline:

- Some facts about new vocabulary, symbols and math
- Why it matters to deal with words, symbols and math
- Strategies for dealing with new words during your first reading
- Studying after your first reading: Collect six aspects of definitions of concepts
- Studying: Major strategies
- Dealing with symbols
- Dealing with math

Some facts about new vocabulary, symbols and math

The most obvious difference about science courses, noticed by students at every lecture and textbook chapter, is the thick wall of words. Yet you've got to deal with words first because words are the legs that ideas walk on. This Study Tip deals with the challenge of vocabulary, symbols and math, and I warn you it won't be pretty. The fundamentals are still the same: Get new knowledge accurately, make associations to the new chunks of knowledge, and make them firm.

Many science courses use a large amount of new vocabulary. A college biology course may introduce more vocabulary than a foreign language course does. One astronomy book's chapter on the Sun used 40 new technical words, many of which would be unfamiliar to ordinary readers. In addition, many sciences often use symbols. They use them to stand for elements and chemicals, properties of objects and events, units of measurement, and parts of formulas. Science courses also include numbers, formulas, graphs, tables and charts because the sciences use math to measure things and events and to summarize the relationships among them.

Words can be hard to learn. Keeping several new words from getting confused is also hard. Research on memory reveals that people learn highly meaningful material far more accurately and quickly than they learn material that is low in meaning to them. Since many technical terms, symbols and math are low in meaning to students, their memory will fade unless they take explicit steps to understand and memorize them.

Why it matters to deal with words, symbols and math

Nearly always, when a textbook introduces a new term or symbol, it defines it immediately. Normal readers who have the prequisite knowledge can understand it at that time. But complications happen. As students read on, the text teaches and the readers read more new words and symbols, and their memories fade for the earlier words. When they encounter an already introduced new word a few pages later, their fragile memory means they cannot recall the meaning of the new word or understand the sentence it is in.

Adding to the difficulty is that the new words refer often to things that students have not heard of. It would be easier if the new words simply named things they have already met. But students must learn both the new concept and attach a new label to it. And if the scientist also uses short symbols for the concepts, as chemists do with elements such as Na for sodium, students must learn the symbol, translate it into the word sodium, and recall its properties—three learnings.
The point is that you must deal with these difficulties. If you don't treat words, symbols and numbers differently than you treat the interesting big ideas, you'll have unnecessary difficulties in learning science.

Strategies for dealing with new words during your first reading

The first reading of a science chapter is special because it is all new to you. Your main task now is to understand the text on the direct obvious level. Later you can get deeper understanding, perceive many relationships among the parts of the new knowledge, relate it to your own knowledge, and commit important things to memory. Since you will read for understanding at the beginning, you will use strategies for new words that do not conflict with getting good comprehension.

- As you read and encounter new words, do not try to memorize right then and there, because the interruption to your reading will damage understanding of the larger passages.
- The most important thing: When you encounter new concepts and new words, do pause and think enough about what the words mean that you understand them at the time. The idea is to have the meaning very clear so that all you are doing is attaching a word to an already understood meaning. Do not read so fast that you are trying to attach a fuzzy word to fuzzy, badly understood ideas.
- Notice the definition, examples, and any graphics that illustrate them. Make a visual image of a concrete example of the new concept if possible. Pause and look back and forth between words, examples and pictures.
- Realize that you may forget the word's meaning later and need to take steps to help yourself.

    - Option #1: Mark the definition. Either write the letter D in the margin or take a felt tip pen and mark the word itself. (There's no need to mark the whole definition because the short swipe over the word will clue you in later to the location.)
    - Option #2: Jot down each new word in a column on a separate piece of paper. Write a short clue to the definition. Put down the page where you found it. Use the list as you read on through the chapter to quickly find and review new words.
- When later you read a later passage and see a word that you have forgotten it, do look it up.
- If you feel annoyed at using time to look it up, think of this: Won't it annoy you even more later on a test if you cannot answer a question because you didn't understand today the sentence that the word was in?
- The above suggestions will help you during your first reading to get as much possible while maintaining your focus on the big picture. But you can do a lot more to learn words by studying and making more contacts with the text material. I will now suggest some useful methods for studying vocabulary, symbols and math.

Studying after your first reading: Collect six aspects of definitions of concepts

During later contacts with science material, your goal changes to finding more relationships and building memory. Whereas you'll understand some of the ideas almost automatically, you will almost certainly need to make explicit efforts to firm up the vocabulary. Your first task is to collect and bring together up to 6 major aspects of new concepts and vocabulary; most writers will give only some of them.

A *concept* can be thought of as an idea in our minds. Writers will try to communicate concepts in several ways.

- The verbal definition is the string of words that say what it is. "A triangle is a 3-sided plane figure." "A social norm is a rule that tells a group what they should do, ought to do, and are expected to do."
- A visual image is often provided to display an example in a visual representation. Pictures and diagrams are common, even in some dictionaries.
- One or more positive examples of the concept are often provided. If we were learning the concept of a dog, a book might give the names of several breeds as positive examples—German shepherds, poodles, collies, and chihuahas. A good text will give a wide range of examples—both obvious examples and unusual ones. The purpose: to prevent students from mistakes that rule out perfectly good phenomena that fit the concept.
- One or more negative examples are also often given. Negative examples are confusing cases that learners might get confused with the real thing. When books name negative examples, they help readers prevent confusion before it gets entrenched. For example, young students might confuse bats and large insects with birds, so a book might name bats and dragonflies as negative examples of the concept of birds.
- A prototype example is an important kind of positive example. Prototypes are really good examples of the concept, so that if you need a concrete instance of a concept to remember you would do well to think of the prototype. People in North America often think of robins as a prototypical bird. And people remembering percentages make up an easy percentage problem in a standard format as prototype (20% times 50 = 10). Then when they get a new question framed differently, they can solve it by taking their prototype, rearranging it, and changing the numbers.
- A unit of measurement is a way of turning a scientific concept into something measurable. Thus temperature can be measured in kelvins which equal degrees Celsius + 273. Measurements need to be learned along with the other aspects of new concepts.
- **Note:** You will find that many test questions will bear on vocabulary and may include examples.

Studying: Major strategies

Here are some important ways to study vocabulary. Be aware that this list does not cover strategies needed for such other learning tasks as building problem-solving skills, learning factual knowledge, studying explanations of scientific phenomena and scientific arguments. The following methods work especially well with vocabulary; use them as needed.

- Use **distributed study** methods. Make multiple contacts with the vocabulary. It is often fairly practical to revisit your vocabulary list many times because the units you are looking at are short. The purpose is to make your memory and associations firm.
- Study a concept and its examples by making **discriminations**, i.e. noticing differences. In other words, take a concept and notice how examples of it are different from related concepts. Go beyond thinking abstractly

how the verbal definition differs from a related concept. Think also of visual or kinesthetic imagery of an example and how the example looks and feels and then compare it to an example of a different concept.

- Study a concept by making **generalizations**, i.e. noticing how far it goes to many examples. Identify unusual phenomena that are examples of the concept. By the time you are done making discriminations and generalizations of a concept, that may be enough to make the concept firm. Your self-tests will tell you.
- Make **row and column charts** of related concepts. List their properties in the chart. The spatial layout taps very powerful potentials of your brain for making visual associations.
- Make **hierarchical diagrams** showing concept relationships. A famous example of a hierarchical chart comes from biology showing the relationships among species, geneuses, families, and so on. The spatial layout will make memory easier.
- **Study and test yourself**. Ask a question, give an answer, and check your answer. Repeat.
- Study by **rearranging** the parts of the definition in the same order that you expect will match the future order of questions and answers on tests or in real-life situations. For example, teachers may start a test question with the word, the verbal definition, a description of a concrete example, or a picture of the concept. Prepare yourself for any way the word starts.
- For your **self-tests** ask yourself verbal questions and give verbal answers. In other words, talk to yourself; avoid vague fuzzy thinking.
- Use **look-away techniques**. (Look at information, look away, ask a question, give answer, look back and check, correct and try again).
- Use **cumulative-addition-to-a-set**. (Study one item. Study a second item, then study both until perfect. Study a third, then study all three until perfect. And so on—up to fifteen or twenty items. Then start a new set.)
- Use **mnemonic techniques** that create images and artificial meanings. The Keyword method is very powerful.
- As your current degree of learning improves, adjust the **time gap** between looking at the word and looking away and giving the definition. As you know it better, increase the length of the delay you insert before you test yourself. When just starting, give the answer right after looking away. As you get better, pause 5-10 seconds. When still better, allow a filled 30-second pause (filled means that you think of something else during the time gap). Finally, give yourself overnight time gaps; in other words, test yourself the next morning without having looked at the material.
- Ask the question about words and definitions,**"Why does this make sense?"** and think of answers as a way to build memory. Sometimes a new word is built on roots that are familiar to you. For example, you may know that *ultraviolet* is high frequency because you know that *ultra-* means something way beyond. You may know that *infrared* is low frequency because *infra-* means something below. If you do not know the word's roots, you may make up a silly answer to the make-sense question. For example, oxidation means that one molecule takes electrons from another molecule. Why does this make sense? Imagine the "ox" in oxidation moving his horns to hook a electron from a molecule.

Dealing with symbols

Symbols are either abbreviations of words (kg for kilograms, K for temperature kelvins) or more abstract as in Greek letters like mu, lambda and delta). Each symbol usually translates into a word. So your study tasks are to associate the new symbol to the word and then make it firm, so that when you see the symbol, you can recall the word, and vice versa. Use the methods described above for learning vocabulary and test yourself.

When scientists measure the properties of objects and events, they use measurement symbols. Then the symbols are used as part of formulas. Formulas involve equations: there are two sides separated by an equals (=) sign. At first you may not find an equation meaningful.

Make an equation meaningful in two ways: (1) Use the text explanation of the principles involved to understand it in words and mental images. (2) Learn the meaning of the symbols; each symbol should match something in the words used by the text. (3) Pick a pair of units, one on the left and one on the right of the equation, and say to yourself their relationship. Pick an item on the left and an item on the right, and say to yourself something like, "As X gets bigger, Y gets smaller." And you can be more detailed. If $2x = y$, you can say, "As X goes up one unit, Y gets twice as big." Notice that this procedure starts by taking two units at a time, no more. The purpose is to minimize the demand on your working memory. After you've got all the parts straight two by two, then look at the larger units in threes and fours until you have a feel for the entire equation. Later when you see the equation again, you will understand its meaning better.

Dealing with math

As with words and symbols, you need to know what your teacher's goals are. A lot of numerical information does not need to be memorized. In certain science situations some specific numbers do need to be understood and memorized. Use some of the methods described above for words and definitions to learn numerical information.

If your task is to solve problems, you will use cognitive skills. Check the Study Tip on learning cognitive skills. Some basic methods are to:

- Study the author's worked-out examples of problems;
- When doing a problem of a new type have a worked-out example problem nearby and use it as a model;
- Practice solving a wide range of problems on the same topic;
- Break things down into steps and learn for each step its specific situation and its current subgoal that trigger you do a certain action, because you must associate three things for each step;
- When you have solved a problem correctly, pause and do two things to build memory:

- Review mentally the steps you took that led to the solution;
- Praise yourself for using the techniques correctly (do not just praise mere raw success).

How to Study Science: Some Suggestions and the Psychological Reasons for Them

Summary:

- Stir up your curiosity to know things before you read and study.
- Organize your time in frequent short sessions.
- As you begin to study, review what you studied in earlier sessions for 3 to 5 minutes.
- For 10 to 15 minutes just read ahead of the place that you will seriously study to get the general idea of what's coming.
- Do both reading and studying in the same session.
- Do self-testing.
- Do a lot of rereading in order to make new and strange ideas familiar to you.
- Compare the new definitions and principles to your existing preconceptions. Notice if you have had any mistaken ideas and correct them.
- As you read new information, think about how it fits into the categories and big problems that the scientific field uses.
- When reading, choose a slow enough speed that you get the meanings of the words.
- When reading, translate words and symbols into pictures, other words, feelings.
- When you study new concepts, learn them 3 ways: the technical definition, the procedures to follow to identify an instance of the concept, and important examples.
- When you cannot understand a section, find another source to read on the same topic.
- When you study, practice discriminating between similar concepts.
- When you study, practice generalizing new concepts and principles to new situations.
- When you memorize, use prototype examples of concepts.
- When you've learned to do a type of problem, make up an easy prototype problem and solution and learn it.
- When you memorize, use both natural memorizing and a mnemonic method like the keyword method.
- When you memorize many things, build up sets of memorized concepts one-by-one.
- When you get stuck in studying hard topics or solving hard problems, MOVE and BREATHE.
- When you get stuck, slow down, check your work, write more on paper, write neater, write in more organized ways.
- When you get stuck on problems, give your mind the order to search your memory or your book for general principles that apply. Look away from the problem itself.
- When you get stuck on problems, look for the specific features of the problem that give clues about what type of procedure to use.

Introduction:

You can do any job in different ways. But using different ways will affect your results: they will work quickly or slowly, be effective or ineffective, and lead to long-lasting results or quickly fading results. It's the same when you try to study science. You can use different methods of studying, practicing and memorizing, but they don't all cause rapid long-lasting learning. What methods work best? Some answers are known. By now psychologists have studied learning and memory long enough to know what works well. This article tells you some of what they say.

Stir Up Curiosity Before You Study

You can increase the amount you learn from a study session by arousing your curiosity to know and learn the material. Try to feel a desire to know the facts and theories that you will study. Do not read with your spirit dead and with just a passive sense of duty.

Why does curiosity increase the amount you learn? Psychologists have discovered that what people really want during the time they do something will influence what actually do. When you read and study, if you strongly want to know something, then your mind will actually be faster to notice ideas that satisfy your goal. If you feel curious about an upcoming topic and can think "I'd like to know about that", then you are likely to spot the relevant facts and theories and not miss them. Also your curiosity will lead you to associate the answers to questions in your mind and build the kind of mental links that cause good memory.
However, if you merely do your homework because it has to be done, you learn less. Your passive motives do not lead you to notice what is important because you have not asked yourself to look for it. Neither will you associate new information to other information because you haven't asked questions that the new stuff can link up with.

Curiosity is a positive, life-affirming motive. You will get pleasure when you learn knowledge that satisfies your desire to know.

If you understand that you can increase your learning by feeling curious, it is natural to wonder next how you can arouse your curiosity voluntarily. And how can you arouse it at times when you do not have any natural curiosity about a topic?

Here is how I stirred up curiosity once. A few weeks ago I was about to read a biology chapter on organic chemistry and noticed that I was making negative pictures to myself about those boring complex molecules. I was able to arouse my curiosity in two natural ways: First, I associated organic molecules to the fact that when younger I had stopped studying chemistry before I got to organic chemistry. I had heard that organic was hard, was the "real thing", and was the basis of medicine. So I thought, "Now I have a chance to find out in a short chapter what it's all about." Second, I knew that my daughter, who expects to study a lot of chemistry and biology, will study this. I could easily feel curious about getting a taste of knowing what she will know. Those two thoughts quickly got me wanting to know about organic chemistry and I read the material feeling curious and alert.

I suggest you do this: First, look over the material so that you know what topics you will study. Next, think of what you really are curious to know. Thinking of the upcoming topics, ask yourself if they remind you of any things you are naturally curious to know about. If so, you're in luck. Finally, take those natural curiosities and think of ways that this upcoming science material can help satisfy your pre-existing desires to know. The science is the means; the pre-existing curiosity is the end. Say to yourself, "I wonder...."

Remember: if you get curious and interested about a subject, you will actually remember it better than if you read it like a drudge.

How to Organize Your Time: Use the "distributed study method".

If you distribute your study time on a topic over several short sessions, you will require less time to learn it than if you study the topic in one or two long sessions. With this method you study your science frequently and you use reasonably short sessions. You also study and review the same topics several times. By using several frequent sessions (a few minutes up to one hour long), you can learn more material and remember it longer than if you study in a few sessions 3 or 4 hours long that are separated a few days apart.

DON'T study your text just once or twice a week in long study sessions. You should avoid letting gaps of time more than 2 or 3 days separate your sessions.

Can you believe this claim about distributed study? I believe so because psychologists have experimented many times trying to find out what method works best. Repeatedly, they have found that the people who study in short frequent sessions learn information in less total time. And their gain in efficiency is a big one, not a little one.

Why do short frequent sessions work? First, they fight forgetting. After each study session, you start forgetting. The more time goes by after studying a topic, the more your memory fades. But if you review material, after a short gap of time like a few hours or a day, you still remember a lot of it. Your act of reviewing revives your memory and makes it much stronger. In contrast, people who don't study often and who leave big gaps between their study sessions forget a lot between sessions. So they have to relearn information that they have almost forgotten. That wastes time.

Second, short frequent sessions work well because your repeated studying of the same material clears up confusions. In the short gaps between study times, your conscious mind rests, but your unconscious mind works and makes interconnections among the ideas. But people who study in long sessions don't get that advantage.

Third, psychologists find that the factor that determines the strength of learning is the number of contacts you make with a topic. The more contacts, the more memory. One long contact with a topic is not as good as several shorter contacts that are separated.

For these reasons, I recommend that you study science by using short sessions several days a week.

WHAT TO DO DURING A STUDY SESSION:

1. Start by reviewing briefly.

Start your study session by taking 3 to 5 minutes to review material that you have already studied. Look at your text or some recent class notes. If your text has chapter objectives, summaries, outlines, and vocabulary lists, review them. Also look at homework and any problems you did recently and remind yourself of the techniques you used. You don't need to reread every single word or problem, because when you look at some of the information, your brain will begin thinking of associations to other topics you studied before but haven't consciously reviewed today.

DON'T start your day's work by jumping cold into a new chapter.

What's the reason? You need to activate the memories that will be relevant to your study session. The brain builds memories by taking new information and associating it to familiar information that you have been currently thinking about. If you have not activated the old information by thinking about it recently, then you cannot expect the new information to link up with it. For example, if you start to read a new science chapter right after talking with a friend, your brain will try to associate the new science information to your friend and your talk. However, if you warm up your science memories by reviewing them for 3 to 5 minutes, then your brain will successfully link up the new science with the old science. That link up will improve your memory for both the new and old material. And your review can be short -- only 3 to 5 minutes.

2. Read ahead.

During each study session include 10 to 15 minutes of reading ahead. I recommend that you set the goal to give yourself an overview, the big picture, of what the science book will be trying to teach you later. Try to just scan it, not read word for word, not study deeply. Choose material that you will normally get to in the next week or so. Scan it slowly enough to get the overall picture. But when you come to difficult material, don't force yourself to understand it. Just read on. Expect that your brain will start to work on it and will make it easier for you later when you seriously study it.

DON'T study blind ahead into new material all the time.

What's the reason? Perhaps you have heard the saying, "They can't see the woods for the trees." It describes

people who are so fixated on details that they cannot see the larger pattern that the details add up to. When you read ahead in science, you will see the woods, see the larger patterns. And psychologists have proven that people who already know what the larger patterns are will learn the small details faster, understand them better, and remember them longer.

3. Both read and study.

It is a good idea for you both to read and to study in the same session. First, read the current material normally. Second, study it, making an attempt to understand it and memorize it. If you also have science problems to do, then you should also study sample problems and do problems on the material you studied. Try to do some problems on the same day that you study the principles. (It is, of course, okay to start problems one day, leave them unfinished, and then the next day to review the text and to finish the problems. That is very desirable. It fits the principle of distributing your studying over several sessions.)

DON'T start to do homework problems in a session where you have not studied the material. DON'T read and study and go away without trying to do some problems.

What's the reason? If you have forgotten the overall patterns of ideas that organize the details, you will see specific details as meaningless. It is harder to slowly study the details of complicated material. So if you can arrange your study time to both read for understanding and study for memory in the same session, you will improve your memory. When you have to study the details on a day or so later than when you read for understanding, then you will speed your learning if you prepare for studying by doing a gentle fast review. It will revive your understanding of the big picture. Concerning science problems: you can't succeed in doing them unless you can mentally associate new science principles with the actual problem-solving methods. The way to associate two things is to link them together in your mind. Any bad study method that interferes with you linking principles and methods and problems will hurt your learning. So you should both study a topic and do the problems during the same session.

4. Test yourself.

During a study session you should test yourself and observe the feedback. This is one of the most powerful techniques of studying available. Whenever you learn something, try to test yourself to see if you know it. Try to do it, notice the results, compare them to what's right and wrong, plan a correction, and try again. One method of self-testing is to do problems. Another method is to study a principle and look away and check whether you can say it. Another method is to watch the logic that your science book uses when it explains something and to check whether you understand every single reason.

DON'T read material and be uncertain whether you understand it.
DON'T make a careless blind stab at problems and omit checking how right your work is.

What's the reason? The major way humans can learn a mental skill in science is to practice the skill and to get feedback that says they did it right or wrong. When people test themselves and notice feedback, they notice what's right and resolve to repeat it. When they get something wrong, they notice it, sense a mismatch between what the result should be and what the result is, and their brains automatically get alert. Our brains are wired to learn by noticing changes, differences, discrepancies. Therefore, test yourself and make corrections.

5. Read new strange material several times.

You should read and reread science material that seems unfamiliar and new to you. Your repeated readings will help it make sense to you. The first time you see and think about new material will often leave you confused. The second time you read it will cause you to notice some patterns in it and make some strange things make sense. The third time you read it will often seem friendly and familiar.

Be sure that you let some time pass between your readings. Why? While the time passes, your unconscious mind is building associations.

Don't plunge into studying and memorizing material that seems foreign, strange, and senseless to you. If you do try to memorize ideas that seem senseless, it will take you longer than if you reread it over a period of a few days until it falls into place.

6. As you read and think, compare new facts and principles to what you thought you already knew. Correct your false ideas.

While you read new scientific findings, you should compare them to what you believe already about the field. Sometimes you will have mistaken ideas, and you need to notice them and correct them. If you deliberately notice how the scientists have different ideas than you do, you will be able to drop your old false ideas off. But if you read carelessly, you may let a few hours or days go by and let your mind revert to its familiar wrong ideas. Then you'll make mistakes on problems and tests.

This problem of students having misconceptions is common in science courses. For example, often when students study the physics' concept of momentum, they can't learn it because their everyday ideas interfere with learning the truth. The same thing happens when they study dozens of other concepts.

The cure: Notice how the new idea compares to what you thought. Correct it.

7. As you read, think how the new information links to the categories and big problems that scientists work on.

If you take any particular fact and link it to a general idea that it is part of, your mind will remember it better. For example, if you read about a specific acid and then think how it is similar to and how different from the general family of acids it belongs to, your memory improves. You have made a link. Easily. Just a few seconds to think as you pause while reading will do it.

This trick of linking facts to general problems and categories is what makes some science writers write well. Many don't. The good ones will constantly tell you the significance of information. The poor ones just tell you the information, and it sits there in a dull lump. The method used by the good writers to make information significant is one you can use on almost any science book. If you use it, it will improve your understanding and your memory.

How can you know what categories and problems to link ideas to? You will partly be able to figure it out as you study the subject. For example, in biology you will notice that you should link biological structures to the functions they perform. You will think in terms of evolution and of "levels" from the molecular up to big ecosystems. In physics and chemistry, too, there are clusters of overarching ideas.
There are also some more general categories that you can use to link ideas to. Look at the list below which comes from the broad concerns of scientists.

- If they see something, they wonder about its causes. (Explanation.)
- If they see something, they wonder about its effects. (Prediction.)
- If they see something, they wonder what its traits are. (Description.)
- If they see something, they wonder what its parts are. (Analysis.)
- If they see something, they wonder what larger wholes it fits into. (Synthesis.)

Good writers, as they write, will focus your attention on big intellectual questions that revolve around the causes, effects, traits, parts, and larger wholes of natural happenings. You will read information and naturally classify it as an answer to one of these questions. You will find yourself understanding the significance of the information because you have classified it--with the author's help.

Now if the author does not help you, you can help yourself if you know how to spot causes and effects and wholes and parts. So here is the recommendation: train yourself to classify what you read into these categories.

Unfortunately, there is a difficulty with what I said. Besides these categories, there are others. When you take physics, there will be somewhat different categories and concerns than when you take biology. And geology differs from chemistry. In fact, each science has some unique concerns. For example, biologists are interested in living things. They are always trying to explain how organisms take in food and excrete, how they grow, how they reproduce, how they move, how they adapt to environments, how their structures (parts) get shaped to perform their functions efficiently. Yes, you will still study causes and effects. But you will learn so much more biology when you focus on these additional specific categories. Similarly with physics and chemistry and geology.

I strongly recommend that you try to figure out the unique categories and the unique intellectual problems that each science tries to explain. How can you find out? Ask your teacher. Check your book's table of contents for the major topics. Read between the lines. Look for repeated topics and questions.

Then once you've got these categories, try to read each new chunk of a chapter and classify the information. When you warm up your mind for a study session, tell yourself to notice these categories. This is another example of the fact that people who see the big picture can learn the details better and faster. When you can think in terms of the secret inner core of concepts that professional scientists use, you will automatically understand the subject better. Look for these big ideas. I promise you: they are there.

HOW TO READ SCIENCE BOOKS

This section of advice applies to the times that you read and study your science book. It is designed to increase your understanding and to prevent mistakes.

1. Read slowly and understand.

Choose a speed of reading that is slow enough for your brain to get the meaning of all the words, symbols, phrases and sentences. This advice comes from a cognitive psychologist. You need to have "adaptive control of your reading rate." You need to adjust your reading speed to how hard the material is. Read fast for easy familiar material. Read slowly for hard, dense new material.

DON'T read fast and merely "get the general idea".

What's the reason? I have to explain a little bit of psychology. When you make your eyes look at print on a page, then information goes to your brain to process. Your brain notices whether the words are familiar or unfamiliar, and it looks up the meaning of the words and phrases. The first signal your brain sends to your consciousness tells you whether you recognize the words as familiar. That signal comes about 200 milli-seconds, or about one-fifth of a second, after your eye sees words. A little later your brain looks up the meaning of the words and sends you a signal containing the meaning of the words. That second signal comes about 400 milli-seconds, or about two-fifths of a second, after seeing words.

So when you read fast, you often miss the second signal with the meaning and catch only the first signal that tells you that these are familiar words. Sometimes, if you're careless, you will be fooled into thinking you understand what you are reading. And at the time when you should be noticing the second signal of meaning, you have read so fast that you are by then reading new words and phrases and therefore are not noticing the meaning of the earlier ones. That situation gives you the false belief that you're understanding a passage when you're not.

Science equations and principles that include short symbols and formulas can cause even good students to stumble, because such symbols look like short sentences. But they are about 10 times as full of meaning as an ordinary sentence! Although fast readers think they've got it, they have gone too fast to think of the meanings.

Your brain's speed of looking up the meanings of the words varies at different times of the day. Your speed also varies with how familiar or difficult the material is. You need to use your own good sense as to how fast to read. So choose a natural pace for your reading speed. Don't ever let a sense of hurry trick you into reading too fast to get meanings.

2. Think of pictures, sounds, feelings.

When you read a science book, translate the words and symbols into pictures, feelings, other words, and sounds. Translate them into what is familiar to you.

DON'T let your thinking stay just on the level of symbols, words, and rules. A common mistake is for students to work on science as if it were only meaningless symbols that they manipulate according to rules.

How do you do it? As you read slowly, give your mind the order to give you pictures of as many symbols and words as possible. Try to see images; even crude ones will help. Your brain can do it. Just ask it.

You can also think in terms of weight and forces and speed. When you read about little things, move your hand and fingers a tiny bit; when you read about big things, move them a lot. Think to yourself that this force is powerful, that object is moving fast or that object is light. And think in terms of physical feelings, as your hands or legs or body would feel. It makes a difference, because it activates the parts of your body that control movement and your brain understands your body movements very deeply. In chemistry you can sometimes work with chemicals and use taste and smell to help remember them.

To summarize, you should translate mere words into meaningful concepts that you can imagine yourself seeing, hearing, touching, tasting, or smelling.

3. When you study new concepts, learn them 3 ways.

When you try to understand and remember new technical concepts, try these three ways (all of them):

- Learn the technical definition.
- Learn the step-by-step procedures.
- Learn the key examples.

This is a bit hard to understand, so think about this example. Consider acceleration. It means to a physicist an object's rate of change of velocity with time. There are formulas that scientists use to calculate acceleration. (1) You would learn the technical definition. (2) You would study the steps you go through to figure out the acceleration of an object. (3) And you would study some key examples like objects thrown up in the air and dropping. You would learn this acceleration at the start, at the top, in the middle, etc. And you would study other examples like a person whirling an object on a string in a circle and like a pendulum. By knowing how to figure the acceleration quickly for key examples, you will save enormous amounts of time on new problems.

Research on learning proves that students who study new concepts in these three ways learn faster and remember longer. So watch your teacher, and if your teacher leaves out one of these 3 ways of understanding, ask for it.

4. Read other sources.

If you read some science material several times and cannot understand it, try to find the information in a different source. It is quite possible that your book's writer did a poor job of explaining the puzzling part. If you find a different writer who wrote better on that topic, you might understand it right away. This technique of studying science by using different books is often used by expert students. They find that they learn much faster and deeper by studying several different writers' explanations of the same topic. And has it occurred to you why your teachers are so knowing? They often prepare for their lectures by researching several books, too.

You can also take advantage of supplementary materials that most teachers can supply you with: posters, videotapes, audiotapes, handouts, etc. Ask other students or your teacher for an additional explanation.

HOW TO DISCRIMINATE AND GENERALIZE AND PROTECT YOUR MEMORY

- There is more to studying than understanding and memorizing.
- Set two more goals: to discriminate and to generalize.
- To discriminate between two things is to see their differences.
- To generalize from one thing to another means to see how the principle in the first thing can be applied to the next.

1. How to discriminate:
When you study a science text and it teaches you a series of concepts and methods to use, you will notice that a lot of them seem similar. Whenever you notice similar concepts that you might confuse, train yourself to discriminate between them. How do you do it? You should pick out the two places in the book or your class notes where the two new concepts are described and first look at one and then look at the other. Don't read the book passively; look

directly from one similar topic to the other, letting your eyes skip over any material in between the similar topics. Deliberately notice the ways they are similar and different. Practice and test yourself until you've got them distinguished. Then you should mark them and should plan to review them in your next study period to prevent forgetting. It is important to do this because some writers don't do it for you.

2. How to generalize:
When you first learn a principle or method, you will study the textbook's examples. But later when you take a test or need the knowledge in real life, you will see unfamiliar examples and will need to remember and use the principles on new unfamiliar examples. Therefore, add the study method of imagining new examples of concepts and principles. Imagine things as bigger or smaller, in different shapes, in different colors. Imagine how a principle applies to different organisms, different environments. Imagine seeing a just-learned technique concealed in a problem that looks different. Think of how a new fact can be connected with others. When you later do the homework problems, continue to think about generalizing and notice the kinds of problems that the textbook writers give you that use that principle. All of these things will help you generalize. They will protect you from seeing a new situation and not recognizing how a principle applies to it.

Why discriminate and generalize? First, it will help you on tests. Most teachers build a major part of their tests around similar concepts that students confuse: that is discrimination. And they use new examples to ask questions about concepts and principles: that's generalization. So if you learn discriminations and generalizations while you study, you will prepare yourself to handle test questions. Second, you can save study time needed for memorizing if you discriminate and generalize. Anything you do that helps you link concepts to one another increases your memory. Third, it will help you in real life because of all the new examples you will encounter.

HOW TO LEARN NEW CONCEPTS, WORDS, SCIENTIFIC SYMBOLS, AND FORMULAS

1. Read first for understanding.
You should first read a chapter or a section through so that you read the new words in their natural context. Don't worry about memory at this point. Your objective at first is to build your overall general understanding of the subject. Later when you start studying the chapter, then you should memorize the words.

When you are ready to memorize things, you will find that some concepts are easy and others are hard. Sometimes you can think about words and symbols and definitions and examples for a half minute or so and know immediately that you will remember them. If so, don't use any fancy methods. Just memorize them simply. If you cannot remember easily by looking and reciting and self-testing, then you should consider using mnemonic techniques. Especially useful for students learning new concepts is the "keyword method". It's a little too complex to describe here. If you are interested in this good memory technique, get Study Tip #2 at the LCC Testing Office. Another useful mnemonic is the "link", and Study Tip #3 describes it.

The last step is to test your memory. The way to test yourself is to look away from the book, ask yourself a question, recite the answer, look back to compare your answer with the real thing, plan a correction and try again. When you have it right two or three times, move on.

(Here is an example of a question that states the definition and asks for the concept: "What is the name of chemicals that have an amino group and a carboxyl group?" Answer: "Amino acids." Here is an example of a question that states the concept and asks for the definition: "What is a polypeptide?" Answer: "A chain of amino acids longer than two amino acid units.")

2. Memorize prototype examples.
When you want to memorize a concept, make yourself a prototype example, a typical example of the concept. For example, a prototype of a bird is a robin, a prototype of furniture is a table, a prototype of a mammal is a cow. In each case the prototype fits the definition. It is a normal example, not an unusual example. You use a prototype to make a visual image or a story image to add to the associations you are making to the concept. When you need to recall the idea later, you can ask yourself to recall the prototype example first. Then you inspect the example and its features and it helps you recall its definition.

3. Memorize prototype problems.

Suppose you are learning to solve a certain kind of problem and you have finally learned how to do it, and it requires a fairly complicated procedure. You will recall it later better when you make and memorize an easy "prototype problem and solution." A prototype is a general example. It stands for lots of examples, even though it isn't exactly similar to any one of them. For example, one math teacher taught students how to remember to do percentages by having them memorize, "10% of 50 = 5". It's an easy percentage problem, and if any part were missing, students could use simple algebra to solve it. Then when they worked on complicated percentage problems that had big numbers (like this: "37 is what percent of 152?"), they went back to their example, figured out how to do it, and then copied that method on more complex problems (X% of 152 = 37.)

DON'T just study examples and learn the principle but carelessly let yourself forget all the simple examples.

What's the reason? People can usually remember a specific example better than the abstract rules. They can remember and copy easy worked-out problems better than general procedures. There's something simple about a specific worked-out problem that people's brains can grasp easily. It increases memory. It rescues you from seeing complicated problems and losing your way.

4. Memorize facts in sets. Build them up one by one.
When you need to learn many new concepts and facts and principles, you will face the problem of overload--too much to learn at once. Confusion. You can cope with overload by using the method of building a set of new terms one-by-one.

Here is how to learn by the method of one-by-one addition of new concepts to a set. First, pick one item. Learn it. It doesn't matter whether you use a mnemonic or the link or repetition and self-testing. Just get to the point where you have learned it. I don't mean sloppy learning, but the ability to accurately state the definition or fact or principle or what-have-you.

After learning the first, leave it and pick a second concept and learn it. Really learn it. Then return to the first and test yourself and go to the second and test yourself. Keep working until you can accurately remember both together.

Then leave them and take a third concept. Learn the third alone. Then test yourself on the first and second concepts and now the third again. Work until you've mastered all three. Then add a fourth using the same procedure, then a fifth, then a sixth and so on.

Build a set of 10 or 15 related items. Start a new set if you switch topics or if a set of somewhat unrelated items gets too big to work with.

I really recommend this method because it makes your learning controllable, it conquers the problem of too many new facts interfering with each other, and it makes it easier to discriminate among similar concepts. You can expect to get big gains in memory power right away. And after you practice this method, the gains get even better.

WHAT TO DO WHEN SCIENCE PROBLEMS ARE DIFFICULT

1. When you've been working on a problem and are getting stuck, the advice is simple. Move. Breathe.
I mean, move your body, breathe deeply in and out, and move your thoughts. For example, wiggle, look out the window. Think of circusses and warm spring days. Think of anything else. Then look back at the material and try again.

DON'T stare fixedly at a problem that blocks you.

What's the reason? If you stare at a problem, you keep thinking the same thoughts that got you stuck. When you are stuck, your conscious mind does not know what to do. Therefore, you need to help your conscious mind by letting in other thoughts that are presently in your deep memory. So you need to detach your conscious mind temporarily from thinking again about the problem in the exact same way that got you stuck. That's why you move, breathe, and think about something else.

2. When stuck on a problem, you can also use the technique of transferring all the steps out of your brain and onto paper.

- Slow down.
- Check your work.
- Write down more on paper.
- Write neater.
- Write in more organized ways with numbers neatly in rows.

One of our math instructors told me, "I'm like most students when I start a problem: I work fast to see if I can get it. But when I can't get it right, I act differently. I treat being stuck as a signal to slow down and organize everything."

DON'T keep working fast when you are stuck.

What's the reason? When a person's mind works fast, the person cannot easily see little mistakes and catch wrong assumptions. It's hard to check your work when you do a lot of it in your head. The purpose of this advice that you slow down and be neater is to give you the information that will let you catch errors and do the problem's steps correctly.

3. When you have gotten stuck by looking at a problem and trying to think of the principles it reminds you of, do this:

Give your mind the order to search your memory for more of the relevant scientific principles and methods that you have available to use on a certain problem. If you have your book nearby, you should physically flip the pages looking for your available resources. For example, I once spent two hours agonizing over a simple problem using logarithms merely because I was trying to use two of the major principles and forgetting there was a third one. If, however, I had ordered my mind to think of all the principles that I know about logarithms, I would have remembered the third one and solved the problem quickly.

DON'T just stare at a problem. Don't just accept the methods that your mind gives you that instant.

What's the reason? Very often people see a problem and passively let the features of the problem remind them of a principles or method to use. If by accident they don't think of the right methods, they are stuck. If, however, they have a way to mentally review all the relevant principles that they have available, they can get unstuck. Such a mental check of principles frees your brain from being caught by strong connections between a certain problem's facts and principles.

4. Try to find the specific features of a problem that signal you which techniques you can use to solve it.

Some experts on teaching math have stated that many students who know how to use techniques do not recognize when to use the techniques. Students need to be able to see the distinguishing features of different kinds of problems and to use them to make themselves think of the techniques that work.

Here's another way to do it: When you are in the middle of doing problems that give you easy clues to help you think of the technique to use, add this mental step: Say to yourself, "Because this problem has these characteristics (and list them), that tells me to use this principle (and say it)." If you do this several times, you will make easier for yourself several days later to see a disguised version of the problem, scan its characteristics, and think of right techniques.

I have in mind that on problem after problem, after you have successfully figured out how to solve it, you will take 5 extra seconds to notice the problems' specific features and notice the techniques that they signalled you to choose. That act of noticing helps you next time you do a similar problem.

Warning to the Reader

If you just read through this article once and put it away, you will inevitably forget most of it. You can't use forgotten techniques to improve your studying.

So don't you think it would be a good idea to save this article? Why not put it near your science books and notes? Next time you study a science book, haul out the article and look at it. Then deliberately choose 2 or 3 methods to

use. After you get comfortable with doing them, then choose a few more and do them, too. Eventually, you will have experience with them all.

Finally, remember that you do not have to use all of these suggestions. I know that you may find something wrong with any one of them. So hang on to your good judgment and use only the suggestions that work to improve your studying.

Situations That Occur in Math and Techniques to Use

Contents:

List of situations:

- You are about to start studying a math textbook
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- You have just finished solving a math problem
- You have just finished solving a math problem and you know you got it right
- You have studied a principle and practiced it and want a handy memory trick for remembering it.
- You study diagrams where the diagram is separated from the labels
- You find symbols meaningless or hard.
- You have done all this and still cannot understand something in a text
- You do not know all the prerequisites on a certain topic.
- You are studying material that you already studied more than a year ago
- You read several lines of material, understand the first part, but by the time you are at the end you forget it and could not put the whole together.
- During a study session your brain gets tired and it's hard to make the material meaningful
- You have returned to a topic the next day and notice that you have forgotten some material
- You have gone 3 days without studying math and are coming back to it
- You have just finished a problem that was both easy to do and similar to others you have done
- You have just finished a type of problem that was new to you
- You have just finished a problem that gave you a lot of difficulty
- You make mistakes on problems because you do not solidly know addition facts or multiplication facts. (Subtraction is the reverse of addition, and division is the reverse of multiplication.) You want a reliable way to learn them.
- You have bad habits in math; once you learned a certain skill wrongly and your "bad skill" interferes with learning the right thing
- You are reviewing for a test: The day before
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- You do not have enough time to study adequately for a test
- You must deal with low self-confidence that you can do a certain kind of math task
- You have to deal with wandering attention
- You will be studying a lot of similar material after math studying
- You sense that there are some weaknesses in the way your text or instructor has organized the material.

Situation: You are about to start studying a math textbook

- Generally, review the prerequisite concepts for three to five minutes. Often you will find that prerequisite material in the prior chapter.
- The purpose is to bring your prior knowledge into your conscious mind so that (1) you will understand the new material in terms of it, and (2) you will save time in memorizing it because you can associate the new material to the correct prerequisite skills.
- If you don't review, you will find your memory is "cold" and it will take you longer to understand the new material.

Situation: You are reading new material in a math textbook for the first time

- What will you see in a math textbook? Usually there are explanations of what a math concept means, ways to use it to solve problems, and some worked-out problems.
- Goal: When you read new material the first time, it is helpful to set the goal of getting an overview and accept that you will not understand the details yet.
- Pick a page or two on one sub-topic and read entirely through the section trying to get the general idea. You will probably find it useful to read naturally and accept it when you do not understand a passage.
- If you don't do an overview of new math material, but try to understand it all the first time, you may, paradoxically, find it even harder because you'll lack a context to fit the new details into.

Situation: You are studying the text for the second time.

- When you read a text passage the second time, read slowly. Pay full attention.
- The purpose now is to get the exact meanings. Read slowly enough that the meanings of the words, symbols, and diagrams come into your mind. This slow reading is especially important for people who normally read fast.
- Get the meanings in terms of separate math principles.
- Try to summarize a principle with a name.
- When you cannot understand, put a "?" in the margin so that you will find puzzling parts later and not forget to clarify them.
- Let your mind also notice what the new principles remind you of, both similar math ideas you already know and prerequisite knowledge. Let your mind go beyond the buildup given by the text. This thinking associates the new to the familiar and speeds up building memory.
    - If you do not take time to notice associated ideas and think about them briefly, you will hurt your ability to remember the math later.
- If you find that a passage is even slightly difficult, then explain it to yourself. Your goal is to make your mental model match the text's ideas. Go line by line, sentence by sentence. Talk aloud. Or talk in your head. Explain each sentence to yourself in other words. Note where your understanding is clear and where there are gaps.
    - If you don't explain it yourself, you will end up with less clear ideas and will not be as aware of gaps and will make more mistakes down the line.
- When it is appropriate to draw diagrams or graphs, do so. Your act of drawing will add a second level of understanding and memory because drawing uses visual-spatial memory.
- Notice situations where the text's ideas are different from your own ideas. Seeing discrepancies between the text and your own mental model are important.
    - When you notice a discrepancy, stop. Think over which is better: the book's or yours.
    - Adjust your mental model consciously.
    - Assuming that the text is correct and your mental model wasn't accurate or complete, then what would happen to your knowledge and memory if you did not notice a discrepancy and consciously fix your mental model? After you shut the book and let time pass, your ideas will tend to return to your original defective mental model. Then later when doing problems or taking tests, you will make mistakes.
- When you go slowly and do these time-consuming things, remember that you are saving time later when you do problems because you won't make as many mistakes and won't have to restudy as often. If you have

never studied before by doing self-explanations and diagrams, you will be pleasantly surprised by the mental power it will give you.

Situation: You are studying worked examples
Research now demonstrates that students succeed better when they study worked examples provided by the text and use them later as patterns for solving homework problems.

- Study worked examples with microscopic carefulness.
- Search for three elements of worked examples: the problem formulation (statement, description), the solution steps, and the final answer itself.
- The way to get meaning in worked examples is to follow three things at each step as you go: (1) What the current goal is; (2) what the current situation is; and (3) what action to take for the current goal-and-situation.
- Explain to yourself what principle the text's authors used in each step to decide how to respond to each goal and situation with the action they took. Normally, the principles will be found in material you studied in that chapter.
- Test yourself by covering up the last line of the worked problem and reach the solution yourself. Then cover the last two lines and finish the problem. And so on until you are doing the whole problem yourself. You are likely to find it easy many times. And when you find you make mistakes, be glad because they signal you don't quite understand part of how do that type of problem.

Situation: You have just read the text and worked problems and learned how to do a procedure
- Practice on a new problem right away. Don't delay. As soon as you have figured out a worked problem, find a similar problem and do it yourself.
    - The first purpose is to save time by using the new knowledge while it is still fresh in your working memory, because in a minute or two your memory will fade. You are most likely to get problems right when you practice right away. If you delay practicing and go on and study additional math, your memory for that procedure will fade quickly, and when you do go back to it, you may have to restudy it, thus wasting time.
    - A second purpose for practicing new material on a new problem right away is to add a second memory—a memory for the experience of doing a problem—to the first factual memory. By putting the information into two memories, you increase your chances of remembering the new material.
- It is generally not helpful to study several different new math procedures at a time before trying homework problems, because you will forget so much. Exception: When the new material is very easy.

Situation: You are planning to do math homework problems
- Do at least some math homework problems in the same session that you study the text and the worked examples. The purpose is to use your new knowledge while it is fresh in your working memory and has not been forgotten. If you delay after you study, you are likely to forget some material and have unnecessary difficulty in working the homework problems.
- Reviewing: Sometimes a good text and teacher will keep giving you a few problems on the same topic for several days through a term. That helps you review. Remember that the more separate times you make contact with the same material and the more you practice, the better you learn. When the text and teacher don't repeat problems of the same type, you can get good results yourself by doing the most important problems over again. Of course, you will find it easier the second and third time. You can't skip steps. You must actually do the problem with pencil and paper over again. The repetition will increase memory both for that problem and for your understanding of how to do problems in that category.

Situation: You are reading a problem
- Translate it: When you read a problem, translate each word and each sentence into what is meaningful to you. Draw diagrams. Make tables.
- Do self-explanations of the problem. Go line by line, talk it out.
- Be aware that research shows that students have the most trouble with sentences that state a relationship between two variables. An example is: "Mary is twice as old as Betty was two years ago. Mary is 40 years old. How old is Betty?" Read such relationship statements slowly and analyze them carefully.
- Integrate it: After you have translated the problem and made it meaningful, then tie the parts together, integrate them, into a meaningful model that makes sense mathematically. You can often tell you've got it when you recognize that the problem is a familiar type of problem, such as a triangle, distance-rate-time, interest rates, river current and boats, and work problems.

Situation: You are actually solving a math problem

- Planning the solution: Do such things as (1) finding a related problem as a starting point, (2) restating the problem, or (3) breaking it into smaller parts and smaller subgoals.
- Executing the solution: Carry out the solution. Be careful. Check your work.

Situation: You are getting stuck on a problem

- A major cause of getting stuck is that your thinking moves repetitively over the same situations, goals, and techniques. You stop searching widely and fail to use the full resources available in your mind, notes, and textbook. Therefore, you need to break up the thinking patterns.
- Move. Move your body, your head, your hands. The purpose is to give your mind some other stimulus to pay attention to so that it will break up the unhelpful circular patterns of thinking.
- Breathe. Breathe deeply several times. Think of your abdomen and do abdominal breathing. The purpose is the same as above – to change your unproductive mental state.
- The classic advice for solving problems that puzzle you is to find a similar problem that you can do. Use it as a model or analogy to guide you in solving the new problem. In this case, use worked examples as such models. Prepare for next time by studying worked examples and preparing prototype problems in advance.
- Reread the problem again carefully.
- Try to figure out what type of problem it is because it's possible you did not recognize the type.
- When you get stuck or find that the text's answer makes no sense and, yet, you seriously believe you understood the text, try to decide where the difficulty lies: in a misprint, the wrong answer in the book, an untaught application, or in your own understanding.
- The final advice is familiar. Go back to the text and reread the parts that bear on the problem. Ask someone for help.

Situation: You do a few problems and find you understand them and are tempted to skip doing the others.

- The issue you must face is to figure out if all the remaining problems are this easy. What you do depends on that answer.
- If they are all this easy, you need to evaluate your teacher's goals: (1) Does the teacher expect students will find the task hard and give more problems than are necessary for you to learn it? (2) Does the teacher know from past experience that students actually need a wide range of practice to build the cognitive skill of solving these problems? You may benefit from doing them all more than you realize.
- Situation: You have just finished solving a math problem
- Find out whether you got it right, whenever possible. Check the answers in the back of the book, ask a friend, or try to double-check the solution. If you skip getting feedback, your brain will tend to recall the bad methods you used as if they were right, and it will cause you difficulties when you use those skills again on similar problems.
- Use this right-wrong information as feedback to how effective your actions were on this kind of problem. Use this feedback to reinforce or correct your knowledge of the procedure to follow.
- Situation: You have just finished solving a math problem and you know you got it right
- Stop for a few seconds before going on to the next problem. Do two things: Reinforce yourself for using the techniques successfully, and mentally review the steps you took to solve the problem.
- Reinforce yourself for using the techniques successfully. Let yourself feel good about success. Talk to yourself in a natural way to praise or congratulate yourself honestly for getting it. "I did it!" "I got that method"! "Yea! I solved it with that method!"
- A good variation is to praise **your ability**to use the techniques. That builds self-confidence for doing math.
    - Your purpose is to reward yourself for your actions and give your mind positive reinforcement for what you did in order to improve your memory and motivation for the future. If you skip feeling good after success, your brain is less likely to recall the procedure and you are less likely to be positively motivated.
    - If you feel grim and negative and determined after you finish a problem, you may be sending yourself a signal to avoid future math homework. If you go further into negativity and call yourself stupid and slow after solving a math problem, you will create even more negative feelings towards math.
    - Do not focus only on the end result of success because that will merely associate praise with success. You want your brain to associate the techniques and procedures you used with praise and rightness.

- Mentally review the problem type and the steps you took. Your review creates a summary. Just a few seconds is usually enough.

    - Your purpose is to organize the separated steps of problem-solving into an organized bundle, a chunk, so that your mind will remember it better.
    - If you skip doing a review and summary, you lower the chances of recalling later how to do this kind of problem. If you delay doing a review of a problem until later, your memory will fade. Take advantage of the time right after problem-solving when all the information is fresh and hot in your working memory.

Situation: You have studied a principle and practiced it and want a handy memory trick for remembering it.

- **Exemplar problems:** You can deal with the problem of forgetting certain procedures by creating an exemplar problem and memorizing it. An exemplar is a real problem that is typical of a category of problems. You can also use one of the text's worked examples as an exemplar.
- Here is an example. Suppose you have trouble doing percentage problems. Create one specific example of a percentage relationship, lay it out and solve it and memorize it. It could be: 25% of 60 = 15. That is the exemplar. Then you know that it translates into a decimal: 0.25(60) = 15. Next you practice swapping the terms: 60 = 15/.15 or .25 = 15/60. Once you've got that solid, you're ready for new problems, no matter what part of the percentage relationship is given and what is missing. A future problem might ask: A department store is selling sweaters at 18% off and you paid $36.90. What was the original price? So you go back to your exemplar that was 25% of 60 = 15. You plug the new problem in. You know you have to figure that "18% off" means that the price you paid is 82% of the original price, i.e. 100% minus 18%. So, 82% of X = $336.90. Next: 0.82(X) = $36.90. Next: X = $36.90/0.82 which = $45.

Situation: You study diagrams where the diagram is separated from the labels

- When the worked example has a diagram (a graph, a geometric shape), sometimes you will experience the difficulty that the diagram is printed up above and the definitions of the parts are printed below. Words and diagram are not integrated. That forces you to go back and forth from the picture's parts to the words below. Research shows that separated diagrams and words cause trouble to students. It is better to integrate the diagrams and words.
    - You can put one finger on a part of the diagrammed object and put another finger on the right label and then look back and forth, telling your mind what the part is.
    - You can write in your own book. Write the label by the part. Use arrows.

Situation: You find symbols meaningless or hard.

- Since math uses a lot of symbols, it can be hard to read and understand. This is normal.
- You can expect that the two hardest times will be (1) when you read and use the symbols on your first contact with them; and (2) when you have been away from the math for a day or more and return to the topic and experience the normal forgetting that occurs after delays.
- Do the normal things to increase understanding: Slow down; pay close attention; talk to yourself about what the symbols mean; treat the symbol as if it is a word and treat the equations and functions that use symbols as if they were sentences, so that you look for meanings both at levels small and large (you treat each symbol as a chunk and treat the whole equation as a chunk); use the symbols in problem-solving; review frequently. Expect the learning to occur within a few days.
- When slow speed of reading equations bother you, check if you find your mind is slow to retrieve the meaning of each symbol. If that is the case, then give yourself speed training. Here's how: Prepare flash cards with the symbol on one side and the definition of it on the other side. Look at the symbol side first and within one-half of a second turn the card over and read the meaning. Next look at the symbol and try to think of the meaning as fast as you can. Practice over several days.
- Situation: You have done all this and still cannot understand something in a text
- I don't need to tell you that you can ask someone: a friend, tutor, or teacher.
- Define as clearly as you can how much you understand and when you don't understand and finally where your understanding resumes. Mark it. That will let you make specific what the issue is.
- The classic next step is to put it aside, move on to another topic, then sleep on it and return to the topic the next day. By then your unconscious mind may have put it together and help you out.
- If next day's studying does not clarify it, back up and go through the topics and procedures that are prerequisite to the puzzling topic. Such information may give clues.

- Once you finally understand it, then do something so you remember it. Protect yourself from the danger of forgetting it. Mark it; review it; practice especially hard on problems that use that topic.

Situation: You do not know all the prerequisites on a certain topic.

- Lack of knowledge of prerequisites will hinder you from successfully understanding math concepts and problem-solving. You need to decide whether to take a prerequisite course or whether you can do well enough to get by.
- Here are some criteria to think about: Do you want high grades? If so, take the prerequisites. Do the missing prerequisites affect a small area, a few topics, or lots of topics? The more your gaps are, the wiser it becomes to take a prerequisite course. The fewer the gaps, the more it is possible to get by. How much time for study do you have? If you don't have a lot of study time, the lack of prerequisites will hurt you more.
- Ask your teacher what to do. A teacher has a broad overview of the role prerequisites play.
- Ask if there are review materials on computer or in a math resource center that can fill in some basics. Perhaps it will be enough to partly fill the gap.

Situation: You are studying material that you already studied more than a year ago

- Many college students take courses that review partly or completely material they had in the past. Your question will be deciding how carefully you need to study and how much of the homework you need to do in order to refresh your skills.
- First, expect that relearning will happen faster than the original learning did.
- Second, notice that there are two kinds of learning involved: (1) factual knowledge, meaning the math concepts and facts; and (2) procedural knowledge, meaning knowing how to follow math procedures and the degree of speed and accuracy you have in solving problems.
    - It is possible you will remember more factual knowledge than procedural knowledge; although you feel you know the principles, you may not be able to solve many problems. That means you should test your knowledge both of the text's explanations and the assigned problems. You might know one and not the other. You may need to do a lot of the problems, even though they are review, in order to build up your speed and accuracy.
- Third, be aware that a college class may include more applications of math principles to different situations than your high school courses did. That means you should look at the full range of problems before deciding you know the stuff.
- Test yourself to see if your quick review is working by doing certain problems two or three days after going to the class that taught how to do them or after looking at the text's explanations. That task will make you pull the material from cold long-term memory. If you can do problems, under those conditions, including tricky problems with unusual applications of principles, know that you've got it.

Situation: You read several lines of material, understand the first part, but by the time you are at the end you forget it and could not put the whole together.

- Sometimes, people can understand parts but cannot put it all together. Although slow readers experience more often than fast readers, it can happen to anyone when a textbook crams a lot of material into a long passage.
- Method #1: Read it bit by bit. Assemble two related bits together and look at what they mean together. Then add a third bit and look at the meaning of the three. Then add another and so on. Purpose: It builds up understanding.
- Method #2: Do a self-explanation. Talk to yourself, out loud if possible where you are studying, and explain in your own words what the author means, line by line. It associates the material to what you already know and increases memory, too.
- Method #3: Do what you can today, put it aside, and come back later.

Situation: During a study session your brain gets tired and it's hard to make the material meaningful

- The sense that new math symbols and statements are meaningless can come often, especially when you have worked for awhile and are tired. What causes it is fatigue of the process of taking sensory information into your mind and then looking up the meanings and transferring them to working memory.
- Method #1: Give yourself a complete mental rest. Take a half hour off and then return.
- Method #2: Give yourself a partial rest by turning to a different math topic or a different subject.

Situation: You have returned to a topic the next day and notice that you have forgotten some material

- It is normal for a time gap in studying to lead to fading of your memory for what you learned earlier. You won't be able to do today some skills that you could do yesterday. You'll forget information you had known. You aren't stupid. It's normal with memory.
- Method #1: Review the earlier material. Review math procedures by actually solving a problem that you solved yesterday. You can expect it to go more quickly on the second day. And when you get stumped and look up what to do, you can expect it easier to find what you need and go on.
- Method #2: Prepare for a future gap in time by over-learning current material today by extra studying. Prepare also by inserting a brief review in a just a few hours, so that the spaced learning effect helps you.
- Situation: You have gone 3 days without studying math and are coming back to it
- A 3-day gap or longer will lead to forgetting. Expect to feel that your knowledge has gone cold. You will need a longer review than after shorter study gaps of 1 or 2 days. This time gap varies with different people. Learn for yourself how long a gap without a review after a study session produce dangerous forgetting.
- Don't skip reviewing because otherwise you will have trouble learning any new material that depends on knowing the earlier topics.
- When possible, try to plan your work so that you work every day or two on math.
- An exception allowing longer gaps in studying would be when you've come to the end of a major section and know that the next topics are independent of the prior ones.

Situation: You have just finished a problem that was both easy to do and similar to others you have done

- Do the procedure of stopping, reinforcing and reviewing.
- Notice whether the problem had any new feature.
- If there was a new feature, do a mental review that incorporates the new feature.
- If the problem had nothing new, go on to the next problem.

Situation: You have just finished a type of problem that was new to you

- After solving any new types of problems, it is especially important to stop, reinforce and review. The reason is that your brain perceived the steps as separate; you probably worked slowly because it was new for you, and the slow speed may have prevented your mind from seeing the whole picture.

Situation: You have just finished a problem that gave you a lot of difficulty

- After doing a hard problem, it is also very important to stop for a few seconds, to feel good, praise yourself, and do a review of the steps you took. The reason is different. While working on a difficult problem, your mind has experienced doing some wrong steps, feeling frustrated, doing some right steps, and getting some success. All these things are mixed up in your mind and you may remember the bad with the good and thus create new habitual mistakes. There is a danger that you might later forget what steps were good and what were bad and just approach a new version of that problem in a wrong way. If, however, you review what the right approach was from start to finish and then let your emotions label those correct steps as "Really good!", then you send a correct memory into your mind.

Situation: You make mistakes on problems because you do not solidly know addition facts or multiplication facts. (Subtraction is the reverse of addition, and division is the reverse of multiplication.) You want a reliable way to learn them.

- Memorizing basic math facts: You can deal easily with certain errors by memorizing basic math facts, such as multiplication tables. You may groan because many students fear they cannot memorize easily. But give me a chance as I explain what to do.
- The laws of how our minds learn are clear: The more we practice, the better we get. You can use that law simply and with few mistakes by following this procedure.
- First, choose what you want to learn. Make either flash cards or make two-column lists of questions and answers that you can cover up. For example, put 8 x 7 on one side and the answer, 56, on the other. (Flash cards are better because you can shuffle them and can discard ones that you have learned.)
- Second, take just one and look at it and look away and ask the question and give the answer. Practice until you've got it.
- Take the second and do it by itself until you've got it. Then go back to the first and repeat it. Then the second, until you've got both of them perfect.
- Then add a third and learn it alone. Then do all three together until perfect. Continue learning more math facts and testing yourself on all of the ones you've learned so far. Keep adding them until it makes sense to quit.

- Do it several days in a row. (Purpose: To benefit from the spaced learning effect.) Continue until you have absolutely got them.
- When you do real homework problems, if you notice you cannot recall a math fact used in a problem, shut your eyes and imagine seeing it on a flash card and see if that brings it back to memory. If not, it's a signal you need to review on it.

Situation: You have bad habits in math; once you learned a certain skill wrongly and your "bad skill" interferes with learning the right thing.

- Unlearning errors in basic procedures: It takes three times as long, on the average, to start with a "bad skill", to unlearn the poor responses and to relearn correct responses than it does to learn a skill correctly the first time.
- Here's how: Get a correct explanation of what to do and a worked example as an exemplar. Study and memorize them. Learn both the abstract general procedure and learn to do the exemplar problem perfectly.
- Over a period of several weeks keep doing problems of that type, even redo the same problem correctly.
- In the meantime, train yourself when you see that type of problem to pause and think of your exemplar problem. Then slowly follow the exemplar's procedure on the new problem. The purpose of doing a pause and thinking of your exemplar is to interrupt your old bad habit from taking control. (You will not always have to pause. Once your new skill is fully established, you can go back to normal speeds.)
- Expect to need to go slowly at first, then to have a phase of going faster, with occasional times that the old behavior pops up, and then to be able to go faster and have very few or no intrusions of the old behavior.

Situation: You are reviewing for a test: The day before

- Practice recognizing the different types of problems that come from different sections of the course. The reason to do recognition practice is because tests add a new task. On a test you must pull knowledge from a wide range of topics. In contrast, when you do a typical day's homework, you just have to remember and use a narrow range of math concepts, symbols, formulas and procedures. When taking a comprehensive test, you must learn to associate the stimulus of each problem to the responses of recalling what type of problem it is and recalling the knowledge of how to solve it.
    - One method of recognition practice is to look at each page of problems you had to do and read typical problems and recall the methods you used. Stimulus – response.
    - A deeper method is to write down key problems on file cards and write on the other side the page or section where the problem is from, reminders of how to solve it, or the entire solution process. Then shuffle the cards. Look at the front of each card and try to recall how to solve it. That method will bring together the material that you learned in separate lessons and train your mind to discriminate the different types of problems.
- It is helpful to test yourself on everything you review. At this phase of your learning, test yourself by looking at information and letting it fade from your working memory for a minute or so by reading something else. Then ask the question and give the answer and check whether you got it right. If so, good. If not, restudy and test again. (Do not test yourself by looking and testing within 15 seconds while the information you just saw is fresh in your working memory. Otherwise, you cannot be sure you can pull it out of memory cold.) It is better still to prepare little tests the day before so that you check whether you can pull it from deep long-term memory.
- Test yourself on vocabulary and definitions, on symbols and their meanings.
- Test yourself on being able to recall and understand the explanations of how to do procedures. Review any exemplar problems you have tried to memorize.
- It is dangerous to learn math without it making sense. Notice if you are just memorizing formulas and the steps in the procedure without actually knowing why you are doing them. The danger of rote memorizing comes when you forget small things, because then you would not be able to figure them, out on the spot during the test. Instead, you want to study in such a way that you could figure out forgotten things.
- Test yourself on how to solve actual problems. It is okay to solve again important problems that you have solved before. You should actually think through the process of solving familiar problems in order to create a procedural memory that will help you on new problems. Otherwise, if you rush through familiar problems, it will leave too weak an impression to help.

Situation: You are reviewing for a test: The day of the test

- If possible, review shortly before the test the most confusing and troublesome material. The purpose is to give you a recent contact with the material, because recency of contact is a major influence on memory. Memory is better for recently contacted ideas.

- Review by testing yourself, so that you actually pull it from memory.

Situation: You are taking a math test: General advice

- Use general good test-taking strategies. Use time effectively; don't hurry; don't waste time on a hard problem as long as there are other problems to do; read problems carefully (research on student errors shows that their hasty reading and misunderstanding lead to a large portion of errors); check your work.
- Ask yourself what type of problem you are dealing with. Often just being able to see that a problem is in a category you have studied will speed up your work.
- Bring to mind similar problems you have seen or solved and use them as clues. Recall the exemplar problems you have memorized when it would help.
- When you see a problem and you know you studied how to solve it and you need to jog your memory, think of what the book looked like in that area, think of the teacher's notes on the board, think of what the room you studied in that day looked and sounded like. These thoughts are associated with the math knowledge and will help you recall the needed math.
- If you cannot go directly to an answer, see if you can use the values in the problem to calculate other values. This is called forward-chaining. It may give you clues.

Situation: You are taking a test: Stuck on a problem

- When stuck on a problem in a test after trying normal ways to recall information, it is important to do something different. Move and breathe, as advised in the earlier section on getting stuck on homework problems.
- Search for "resources" in your memory. Resources are knowledge that you can use. Recall principles, explanations, worked examples, formulas, definitions, and procedures for tackling problems.
- As you prepare to temporarily leave the problem, start thinking of other things associated with it when you learned the knowledge and skills in class, text, and homework. The purpose is to start your mind making associations to what you know so that your unconscious mind may retrieve what you need to know. (Even random associations may jog your memory.) After doing other problems, check back on the problem. When you check back, do something to make it look different: Use a new section of scratch paper. Organize your solution efforts differently.
- Assess how much time you have. If you haven't done other problems, do them first before investing more time into the one you are stuck on.

Situation: You do not have enough time to study adequately for a test

- Set priorities. You will need to figure out what are the most important things to pick out and study and which are less important. Your purpose is to prepare yourself as well as possible by selecting the most important topics.
- One strategy is to expect that the teacher will include something basic from every chapter and every major topic on the test. Therefore, it might be useful to learn the basics on every topic and skip the complications. You would actually memorize basic concepts and symbols and problem-solving procedures. Make sure to actually learn them.
- Another strategy is to minimize the time you spend in solving homework problems and to compensate for your undeveloped skills by over-studying worked examples and by creating exemplar problems. Then you would approach problems on the test by using your memory of the concepts and exemplars to figure out on the spot how to solve them. However, try to solve at least one problem of each type.
- Do not study everything shallowly because then you will not have much chance of getting at least some problems clearly right.
- Do not study only one chapter or topic thoroughly and abandon whole chapters, because, in emergency studying, it is usually better to get some fundamentals on everything. (**Note:** Different teachers have different approaches to setting priorities. Ask.)
- Prepare yourself emotionally for accepting a lower grade. Remind yourself that it is better to learn part of it than to not learn any at all.

Situation: You must deal with low self-confidence that you can do a certain kind of math task

- Taking a math course challenges most people's self-confidence at one time or another. After all, you learn one thing and have to move on to something else new. It's detailed and hard; you have to solve problems. People have to fight the fight of believing they can succeed.
- Our unconscious minds send us negative feelings. We catastrophize; we feel disaster is ahead.
- Staying positive requires that we use our conscous minds to think positive. Take deliberate charge of your thinking. Here are some tips.

- Keep thinking over the knowledge and skills that you do have. Give yourself credit for learning. Keep saying, "I am learning." "I have the ability to learn."
- Remember that it is normal in math to have to learn something new almost every day and normal to make lots of mistakes. When we learn new things, we revert to a slow learning mode, halting steps, and needing lots of time. It's normal; it happens to everybody except for a few high aptitude people. Keep saying, "Just because I'm going slowly and making mistakes is not a situation that predicts I'm going to fail."
- Set beginner's goals. Do not set goals and expectations for yourself that are too high. You'll feel better.
- Study worked problems; they are your friends. Use them as models for solving homework problems.
- Remember that it is normal when taking math to feel strong feelings. People feel frustrated, angry, and worried; they want to escape. Do not confuse strong negative feelings with a sign that you are going to fail. Say to yourself, "Yes, I hate math. But I can still do it." "Yes, I'm angry at the teacher, the text, and myself. But I can still learn math." "Yes, I'm worried that I'll fail, but even worried people can still succeed."
- Situation: You have to deal with wandering attention
- It is very rare for people to be able to focus their attention on something for a long time. Our minds wander constantly. When people's attention wanders, they often pull it back to their math in the wrong way. Here is how to handle a wandering mind.
- First, intend to pay attention. The reason for setting the purpose intentionally is to help you remind yourself later that you really want to focus on your math.
- Second, when you notice your attention has wandered and you are thinking about something else, turn it back to your math. Pull it back without criticizing yourself or feeling bad. The reason is that our minds take what we are thinking about and start thinking about additional memories. You may say to yourself something like this: "There I go again. Idiot. I have no self-discipline." Your nice obedient mind will start calling into your working memory some more associated thoughts about this bad tendency, memories of other times your mind wandered, and negative thoughts about failing. It fills up your working memory with junk and slows down your work. You want instead for your working memory to have space for math information and problem-solving goals. So just quietly turn your mind back to the subject. Be at peace.
- Third, return your mind back to a point a little before where you were when your mind wandered. If reading, go back a sentence or so. If solving a problem, go back a step or two. The purpose is to help you reinstate in your working memory the information you were thinking about before your attention got diverted.
- That's all. One research team gave low-achieving students these directions for dealing with wandering attention and did nothing else. Their grades rose significantly!

Situation: You will be studying a lot of similar material after math studying

- When you study a lot of material in long study sessions, it is possible for the various chunks of information and skills to interfere with each other and lessen your memory. Psychologists call it interference.
- Interference is worse when people study a lot of similar material together. It lessens if they break up the studying by doing something different between study sessions.
- Try to study in relatively short sessions. For example, study math for 20 or 30 minutes and then read some English or History for a bit and then return to math. It's important to change to quite a different topic. Research shows that people can study in long sessions with low interference as long as the topics are very different.
- Use spaced study. Study the same topic several times over a period of several days.
- Use techniques that help you discriminate and compare concepts that look similar. You have probably noticed that certain math concepts, symbols, procedures, and formulas seem alike. Study by gathering them all together; look back and forth and notice how they are similar and how they are different. That technique will lower interference.
- When you know you have to learn something hard, study it the last thing before you go to bed. Sleeping means that no other knowledge will enter your mind and interfere with the last learned knowledge. This is a serious research finding.

Situation: You sense that there are some weaknesses in the way your text or instructor has organized the material.

- **Spaced practice:** It is common that there is not enough spaced practice provided by text or teacher. Instead, a different topic is given each day. When that is the case, give yourself some periodic practice sessions on old topics and problems. It will greatly increase your memory.
- **Discrimination practice:** Some textbooks do not provide enough practice provided in discriminating topics that look similar but are different. You can handle this problem by looking at each new topic to see how the concept is unique, distinct, and its own self. Keep thinking: "This is different. How is it unique?"

- **Generalization practice:** Some textbooks do not give enough practice in generalizing knowledge from instructional examples to far-flung cases that use the same principles. It is important to be able to transfer your knowledge from the teaching examples to unusual problems that still use the same principles. Often tests and science classes will use these extended applications of basic principles.
    - You can help handle this situation by trying to grasp the underlying principle and by looking at problems and getting in touch with the underlying them in them. Deep analysis of the patterns under the surface helps you generalize.
    - Ask your teacher if the procedure you are learning has far-flung applications.
- **Isolated small chunks:** Sometimes texts teach topics in little bits and you cannot see the overall whole. Some textbooks look well-organized but a reader ends up not being able to see the woods for the trees. They are good at separating, but weak at bringing together. It can hinder your ability to handle homework problems.
    - First, you can help by surveying chapters to pick up the main theme; try to see how each of the parts is linked to the others.
    - Second, it is helpful to ask teachers to talk about the overall pattern, because they will see it clearly.
- **Worked examples:** Sometimes texts give too few worked examples. Sometimes texts do not explain fully why each step is there. Since you will use worked examples as models to use when you work on homework problems, poor ones hinder your transfer to problems.
    - You can help by doing self-explanations of worked examples. Go line by line and explain to yourself what is new, why it is there, what it shows you.
    - Look for three things in each step: (1) What the current situation in the problem is; (2) what the current goal is; and (3) what the right action or step to take is.

How Math is Different

Math is different from most other fields. Many students find that using their ordinary methods of learning and studying does not produce the grades they can get in other subjects.

It is different in these ways:

- Students have to both learn abstract principles and build up skills in following procedures, many more procedures than required by other fields. Studying to build procedural skills is somewhat different than learning factual knowledge.
- Students need to learn math sequentially; the later skills build on earlier skills. Students who haven't learned earlier skills fully often have trouble learning later skills.
- Students practice by solving problems; they are tested by solving problems. They will rarely be tested by essays or factual recognition items. Learning to solve problems skillfully requires different techniques than the ones used in learning facts, theories, science and literature.
- Students must read math information that is presented in symbols. The symbols are packed with information and require a different reading style than used in reading ordinary books, one that is very slow and careful.
- Students often find that math symbols and formulas are abstract and meaningless to them. Different techniques are required to study abstract material and to make it meaningful.
- Students usually find that a lot of math is new to them; they don't have a built-up body of knowledge to link math to. In contrast, many students already know a lot of information that they can associate to material in literature, history, social science, and much of science. The task of learning new material makes a lot of memory demands.

The Goals of Studying Math

How do you know when you are finished with work? It depends what your goals are. Since math is usually tested by giving students a series of problems to solve without the use of notes, students' math goals are to learn the knowledge and skills to solve problems, without notes, and within the time limits.

- **Goal #1.** To learn some ordinary knowledge and facts. Some examples are multiplication facts, formulas, the meaning of math symbols, the logic of equations, how to factor equations, what logarithms are, what graphs mean. One's goal is to build ordinary memory for information. This kind of memory can be built by

ordinary review and memorization and associating the different chunks of information to each other. Each chunk can be learned in a few minutes.

- **Goal #2.** To learn skill in procedures for using math knowledge to solve math problems. One also needs to build up speed and accuracy in following them. We cannot learn procedural knowledge by ordinary methods studying to learn information. We must solve problem after problem by using the knowledge and procedures, and we get faster and faster, more and more accurate. The time taken to achieve solid procedural learning can involve 40 or more repetitions of a procedure over a period of many days.
- **Goal #3.** To learn how to approach problems as a category in themselves. Students need to learn the normal problem-solving tricks.
- **Goal #4.** To deal with the normal obstacles that occur: coping with gaps in knowledge, handling feelings of math anxiety and low self-confidence in one's math ability; dealing with imperfect teaching by the textbook and teacher; handling the time demands; and reacting sensibly when stuck on a problem.

Basic Methods That Are Used for All Studying

When people study for the purpose of building knowledge, memory, and procedural skills in any subject, there are certain standard methods that people often use. The brief descriptions below will remind you what they are. For further details see this writer's set of study tips or other books on studying and memory.

Overview

- Study each new chunk of knowledge until it is familiar and well-learned.

- Study the chunk of information or the procedure carefully and repeatedly until it is very familiar. You want it to be clear and solid in your long-term memory so that you can recall it even when you haven't thought about it for quite awhile. (Psychologists call it "having a high base-level activation".)
- Associate the new chunk firmly to other information (make associative cues).
    - Association: Whenever you learn some target chunk of information, also associate it to something else that you expect will be present at a time you need to recall the target. Then practice until you can think of the associated thing and be reminded of the target. By associating one item to a second one, you guarantee you can retrieve the studied item. For example, it is common in math teaching to teach students to associate addition to problems presented in words, in numbers given horizontally, in numbers laid out vertically. Those three associations should trigger memory for addition facts.
- Practice the knowledge or skill shortly before you will need it (within the hour before).
    - Recency of contact: When you expect to need information or a skill, practice with it shortly before the task occurs. It is known that the more recent a person's contact with a bit of knowledge, the more activated it is and the more likely the person can recall it. With math this fact suggests that you start a study session on new material by reviewing relevant older material. When you are going to take a test, it suggests you review the harder material shortly before to make it fresh in your mind.
- Pay close attention.

    - Attention: When you think about information, pay close attention to it in order to give your memory image of it the strongest activation possible. Don't give it half your mind or else the learning will be weaker. When you pay attention to an idea, your mind will automatically associate to other ideas it is associated with. If you pay weak or divided attention, your mind will not associate as well to the related topics.
- When your attention has wandered, return it to the material without self-criticism.
    - Inevitably, your attention will wander. That is normal. Return your attention to the topic very gently without condemning yourself and without talking to yourself. If you criticize yourself as stupid and weak for having distracted attention, then your obedient mind will start thinking of other reasons why you are stupid and weak and will put them into your working memory. You don't want that extra stuff in your working memory along with the topic you are studying. Rather, you want as much as possible of your attention and working memory to contain the new information.
- Assemble very small bits of new material into chunks. Break large amounts of new material into smaller chunks. Work with chunks.
    - Chunks: When you are studying new material, break it into small chunks of new information. The first purpose is to fit it into your working memory, which is limited. It can only hold a few chunks of information; and without review they will fade within a minute. The second purpose is to organize

information into sensible parts that are bite-size. Don't read too much material and then try to practice with it.

- While you can still remember new material in working memory (15-20 seconds), think about it and make associations to it and practice it immediately.
    - When you are building memory for brand new information, do your thinking about it and use it in practice within a few seconds of receiving the information. If you don't think immediately about it, it will fade from your working memory, and then you'll need to look at it again, thus wasting time.
- Practice recalling material that you have already partly learned after it has faded from working memory (1 to 2 minutes later). This advice is opposite to the method you use on brand new unlearned information.
    - Medium-learned information: After you have successfully begun to learn new information and have it partly memorized, then you change your method. You look at it and intentionally let enough time go by so that it has faded, and then try to recall it cold.
- To learn new factual material: ask yourself how it makes sense and give an answer.
    - When you learn factual information, use the method of thinking of how it makes sense in terms of other information that you already know. Example: The capitol city of Oregon is Salem. Ask yourself: "Why does it make sense that Salem is the capitol?" One answer might be that it is in the center of the populated Willamette Valley where pioneers first settled..
- To learn new procedures and build skill: study worked examples; break each step into the current goal, the current situation, and the right action; practice many problems over many days.
    - When you learn procedural knowledge (for example, how to divide fractions), study an example of the procedure and then do a new example, new problem. Study worked examples and generalize them to new problems that you solve yourself. Break each step into three phases: the current subgoal, the current situation in the problem, and the right step to take. You'll repeat this 3-part pattern for every step in the procedure. Solve many problems.
- Space your study of factual knowledge and your practice of skills over many sessions.
    - Don't cram study and practice into one long session because it is not nearly as effective as spaced learning. This applies to learning meaningful and not-so-meaningful information like names and dates, to practice of cognitive skills like writing with correct grammar and using new math procedures, and physical skills like playing instruments or playing a sport.
- To learn material that is relatively meaningless to you (proper names, symbols, dates, arbitrary facts) you should use special methods and test yourself to make sure you've got it.
    - Although it is comparatively easy to learn things that are already meaningful, people typically find it hard to learn and recall such meaningless information as new symbols, proper names, historical facts and dates. A lot of math also seems that way. Here are several possible ways to cope with material that is not too meaningful: Use mnemonic methods; prepare flash cards; find ways to make it meaningful; use even more repetition than usual; test yourself often; and use spaced learning over a longer period of time.
- Translate verbal material into visual and spatial representations. Also use representations that are kinesthetic, emotional, smell, taste, lists or sequences, and story formats.
    - Use visual and spatial representations of material in order to get two results: (1) to make meaningless material more meaningful; and (2) to build associations to the new material that will help you recall it better later. In math draw diagrams and graphs and look at them while also thinking of the general principles. You can also use other representations. Examples are kinesthetic (how your muscles feel in movements), emotional feelings, smell and taste, lists or the sequences that things occur in, and story formats.
- Don't read or work so fast that you outrun your mind's natural working speed in giving you meanings.
    - Our minds have a natural speed of working. Don't outrun it.. Some people read faster than their minds can figure out the meaning of what they are reading, and the result is poor understanding and poor memory. People who can read normal fiction and non-fiction quickly will also try to read math at the same fast pace and run into trouble. Because math is heavily symbolic and condensed, one needs to slow down and decipher each symbol and then put the whole thing together. How can you tell whether you are reading at the right rate? Notice whether everything is meaningful. If it's not, something is wrong.
- Correct misconceptions and bad habits.
    - When you have inaccurate knowledge or misconceptions about material, then you must unlearn it and replace it with new and accurate knowledge. When you have learned a "bad skill" so that you do a procedure wrongly and have unfortunately done it so often that it is stamped in, you will need to explicitly unlearn it. You cannot usually substitute new knowledge very quickly for well-learned old

knowledge. One expert found it can take people three times as long to unlearn and replace their bad skill habits as it took to learn a skill new from scratch. In math it can show up as habitual mistakes. Examples: You may think that 9 x 7 is 56 instead of 63; or when subtracting you may forget to borrow when you subtract a bigger number from a smaller number in that column. Since your old knowledge and skills will "fight" the new knowledge, be sure at first to practice very slowly, to pay attention, and to practice away from real life situations.

- Set specific goals for your learning. Define the accuracy and speed of learning you want to attain today. Define the amount of material you want some memory of today.
    - After trying to learn and remember something, test yourself by trying to recall the knowledge or do the skill, notice your result (feedback), and compare the result to the goal you set. Notice how well the result and your goal match (feedback). If they do not match, study again and try again with a correction. And so on.
    - When setting goals and getting feedback, be sure to call to mind what you did so that you can compare what you did to the feedback. It is easy to do when feedback comes instantly. It is harder to do when you do homework and there follows a delay of a few days until the teacher grades it and turns it back. After such delays look at the missed problem and retrace your mental steps so that you can label the errors as errors and so that your mind will remember to do what is right next time. Do not passively look at feedback because then it cannot help you learn.
- Intentionally learn concepts in several ways.
    - Our minds abstract "from specific experiences to general categorizations of the properties of that class of experiences" (Anderson, John R., Cognitive Psychology and Its Implications, 4th ed. New York: W. H. Freeman, 1995, p. 131). We call these concepts. We see many examples of dogs, apples, carrots, houses, fast motion, upward movement, and so on, and we stop treating them as unique experiences and start creating concepts of dogs, apples, carrots, etc. In addition, people and books who teach us things will directly teach us concepts.
    - We do several things to identify and remember concepts: we use positive examples and negative examples, memorize exemplars and prototype examples, learn definitions, and follow procedures for measuring the values of a concept.
- Learn schemas and associate new information to useful schemas.
    - Our concepts are often organized into larger sets of concepts regarding events and complex things. These sets are often called schemas, scripts or frameworks. These large sets of concepts include standard things that always are present and the varying things and events. Knowledge of baseball schema would include knowing about batters and 3 strikes, 4 balls, hits, fouls balls, and so on. It would include knowing that different hitters have different experiences. Some other examples: knowledge of what happens during a typical visit to a restaurant; knowledge of how to use e-mail and the world-wide web; basic ideas of levels in biology from molecules, parts of cells, cells, tissues, and so on up to ecosystems; knowledge of football games; and understanding of the typical structure of stories and novels.
    - Teachers and tutors who can find good schemas, complex metaphors, and structured frameworks can greatly speed up and deepen their students' learning. In fact, one of the very few fast ways to learn is to turn on the relevant schemas while studying new information.