The Biology Of Learning

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Introduction: It is impossible for you to learn all that there is to know for any subject as information is expanding exponentially. Long believed "facts" are disproved. Despite our repeated observations to the contrary, the earth is not flat, matter and energy are synonymous, and time is relative. Thus, regardless of our efforts to learn, new "facts" will likely contradict that which we have already learned. So, it is not your knowledge of facts but your ability to learn, to gather, remember, and process facts and apply them in decision making that is the proper goal of college. It will be your acquired "learned" ability to recognize problems, pose questions, and solve problems that will make you an educated and capable person. A college degree represents your ability to successfully complete volumes of work, meet deadlines, solve problems, fulfill assignments, and above all to properly communicate. Further, it testifies to your reliability; you showed up and did your work. These are the requirements of "success" in most all of our present day endeavors. Many studies have demonstrated that "success" as measured by achievement, influence, and earned income is statistically correlated with years of education. Such success is not correlated with family wealth and power, race, ethnicity, or country of origin (Nie, 1996). Education is your goal and learning to learn is your work at college. Knowing what happens in your brain will help you “learn to learn” and taking a learning styles survey[2] will suggest the best study strategies for you.

The process of learning is an active field of scientific study in biologic sciences including biochemistry, brain imaging, and electrophysiology, as well as in psychology and education. Herein, I present you with some information to help you understand what happens in your brain when you learn so that it might help you organize, manage, and use the large amount of material you must master during your college career. Learning starts by communication and communication requires language, either written or spoken. The student must understand the language to proceed and by this I mean that the words used must mean the same thing to the instructor and the student. Introductory biology has more new words in the first semester than most introductory foreign language courses. So we must start out with clear definitions. Learning is the process of turning information into knowledge. That is, establishing information in your

memory that can be recalled and used. It is not something that happens to you, it is something you do.

LEARNING: Learning is a biological process; it happens in your brain. We know this by experiment and observation. It has long been known that people with brain damage in particular parts of their brain will demonstrate different learning, behavior, and/or information deficits (Harlow, 1848, Harlow, 1868; Miller, 2001). Scientists find biochemical, physiologic, imaging, and anatomic changes in the nervous systems of animals, including humans, subjected to learning experiments. Some of the most exciting "brain location maps of memory" were demonstrated by Penfield and Rasmussen who stimulated the brains of patients during epilepsy surgery and elicited vivid memories (Penfield, 1950). Interconnected brain nerve cells, webs or networks of neurons in your brain receive and send signals to other webs of neurons when you are presented with and "learn" educational material (Nolte, 2002). Learning new material generates new connections and new proteins in your brain (Mandeville, 2002; Kempermann, 2002;). You have between ten and twenty BILLION interconnected neurons in the cerebral cortex alone and perhaps five to ten times that number of supporting cells (Nowakowski, 2002). The number of connections or synapses of these cells in the cerebral cortex has been estimated on the order of ONE TO TWO HUNDERED MILLION per CUBIC MILLIMETER of cortex! (DeFelipe, 1999). You must activate a few of these to learn! There is plenty of room in there; just train yourself to use it. So how do we learn?

The process of learning has two separate components, (1) understanding and (2) remembering and both are necessary.

STEP ONE: UNDERSTAND THE MATERIAL.

(1) Understanding: When you encounter new information you must first understand it. This requires the coordinated activity of a lot of webs of neurons until one or more of them "recognizes" it and the "light goes on." You know when this happens. Sometimes it takes repetition or analogies [resemblance between things otherwise unlike (Merriam Webster On- Line)] to "bring it home." Such analogies bring in additional brain cell groups to attack the problem. If you still don't understand, you haven't tried enough circuits in your brain. In this case you have to open up more circuits by getting an explanation, discussing it with other students, or you have to read more background material to enlist other neurons to help. Until you do this

and understand the information, you can not learn. This may seem obvious common sense, but you would be surprised how often we forgo understanding to "save time." We all do it.

STEP TWO: REMEMBERING.

(2) Remembering: For learning to be complete, the understood material must be committed to memory and for most people this is the most difficult part. This is turning information into knowledge. Some understanding of how the brain works will make it easier for us to devise ways to complete the learning process. Information first taken in is processed and some of it is selected and stored in short-term memory. To do this you must focus on the information and organize it in understandable pieces. In short-term memory, the new "information" may be integrated with old "information" to become "working memory" for understanding and use (Baddeley, 1997). Here is lesson one of memory: it is easier to process new material if there is relevant information already stored. But short-term memory is short term and to be "learned" information must be transferred to and embedded in long-term memory for later recall. This is your task.

How do we do this? The reason that material is forgotten is that the connected webs of neurons are not all permanent. It is well established that if new informational connections are used a lot they will be retained and then established in your long-term memory; if they don't get used they are lost (Gabrieli, 1999). USE IT OR LOSE IT!

It has also been established experimentally, that new information is easier retained if it is associated with something with which you are familiar. This can be affected by repetition and expanding brain exposure to additional linked visual and/or auditory stimuli. This also explains why someone who is "interested" in a subject has an easier time remembering information. This student has an "emotional" connection to the material. In fact, the more you know of a subject, the easier it is to learn because you have somewhere in your brain ready to receive it (Gabrieli, 1999).

"But I am not interested in _____ " (fill in the blank.) Knowledge builds interest. Build a knowledge base about anything - develop those neural web connections- and bingo! You will be interested. I guarantee it; it will enrich your life and fill it with great and unexpected pleasures. Once you learn to build new knowledge bases in new subjects you expand your

universe and your capacity to be interested, hence the capacity to learn easily and succeed in many areas of life. College is the perfect place to become interested, to take classes just because you are curious. Now we know that learning is both understanding and remembering. What you have to find out for yourself is what the best methods are for you to convert information into knowledge. How can you best train your brain to do these things? It is called STUDYING.

HOW TO STUDY: The word "study" is often used but it is something different for each student. (Take the learning styles survey[(2)] to see what type learner you are.) The most serious misunderstanding for many students is that studying is what they do for a test. Many students go through college thinking that they study hard because they stay up late on the nights before an exam to read the text and class notes.

Studying is what you do to commit the material to your knowledge base, turn information into knowledge, grow your brain and develop your abilities of understanding. If you have a sense of unease, of having to cram and stay up all night before an exam or if you are approaching the material for the first time that night, then you have made a major mistake. You are not learning the information, you are simply committing it to short-term or working memory to regurgitate onto the test the next day. This is a short term gain at the expense of not really "training your brain."

Try a different approach to truly integrate the information into your long-term memory. First, prime your brain; study the assigned text before the lectures. That way you will find the lecture familiar (your brain will connect things with greater ease). Take notes during the lecture, and try to reconstruct the lecture after class. It helps "cement" things if you re-write your notes in whole sentences or try to give the lecture aloud yourself. This will be a good test of understanding and help transmit the information to long-term memory. You may be surprised to find that this takes less time then your previous methods.

When you are reading the text prior to lecture, you need to know how to approach a textbook. A textbook is not a novel. Therefore, read a block of material and then ask yourself if you understand it. Repeat the main points verbally. Underline, highlight or otherwise isolate and emphasize each and every idea and fact. Be engaged, focus and concentrate, keep your brain working while you read. Make notes in the margin of the text. Make flash

cards with a word or question on one side and answer on the other (keep it simple, flashcards are meant to chop information into small, easily digestible chunks, too much information on a flashcard defeats the purpose); some students use a spiral notebook and make a question on one side and an answer on the opposing page. These techniques allow you to test your knowledge and provide repetition (this also allows the information to be stored in different areas of your brain, i.e. if you read it, say it, and write it…you have stored that information in three different places.) "KNOW WHAT YOU KNOW and KNOW WHAT YOU DON'T KNOW!!!!"

Answer the questions at the end of the chapter. Take the time to do it. If you have trouble with one or more of those questions, go back and find the answer in the text. This allows you to see the correct answer within the context of the rest of the chapter; thus, allowing you to relate it to the rest of the information presented there.

The two main strategies are repetition and elaboration. Repetition keeps it in your short-term memory as long as possible and elaboration stores it in several places and combines it with other information for long term memory storage (Mayer 2003). These are what stabilize your new brain cell connections. Elaboration, which means multiple types of stimuli, writing, drawing, verbalizing, etc. also help reinforce and stabilize information as knowledge (Diamond, 1998). Studying is much like learning a musical instrument it takes practice and with practice you get more efficient.

I encourage, you to read your text and notes between classes or when you have just a few minutes. Try this time to make flash cards or use other new techniques for learning, experiment. Answer the questions of the study guide well ahead of the exams. Work with other students in the class. Find your own techniques to expand and test your knowledge.

TIME: We all have many competing activities and it is difficult to prioritize. However, to acquire any knowledge or skill takes time. If I could, I would simply use a couple of computer USB ports and transfer to you the knowledge you need for your courses, but that is not possible. Your attitude toward your studies and your priorities belong to you. So set aside the time for proper study habits. Don’t think it’s cool to study just a few hours before an exam. Don’t cheat yourself of these important years. This is a huge

opportunity. Efficient use of time and the ability to apportion work is a major part of a college education; it is what your degree signifies.

MOTIVATION: It is fair to for you to ask why you are in college. Of course there are several reasons but among them should be to "get an education." By this I mean for you to build a knowledge base about a lot of subjects. In addition to training your brain to enable you to do a lot of unrelated jobs it will make your life more enjoyable. Herein you will note the difference between building a knowledge base in your long-term memory, one that lasts, and creating short-term knowledge that is lost just to pass tests[(3).] Attitude and motivation are the things you can control with effort.

EXAMS: Frankly, most Professors feel pretty much like the students; they do not enjoy the process of testing. It is not why we teach or why we chose our disciplines. It has, however proven to be the most reliable method of assessing student progress and the effectiveness of instruction, and is also unfortunately, the major stimulus to study for many students. That said, if you have prepared as recommended you will have good comprehensive notes and flash cards or other devices to allow you to test yourself on the upcoming material for an exam. First you must review your material. “Review” means “to learn again” or to strengthen the brain connections that you already built. It does not mean, “to see for the first time!” Establish "what you know, and what you do not know." No one can "learn" the content of multiple lectures and text chapters in two days. If you are in this situation your anxiety state and fear will further complicate the problem. So, after the first review, spend some time with other students and explain to each other important concepts and facts. This will further identify "what you know and what you don't know." Prepare summaries ahead of time for major topics. Use study guides when offered. It is frequently good to divide up this task with several students. This both reduces study time and allows each student to test their knowledge by explaining their topics in a study group, elaboration.

The discipline of preparing for a test is good training for future responsibilities. Also, if you prepare early enough you will know where you need help. Tutors are available to help you clarify things in the science building at the Learning Resource Center on the second floor of the Science

Building. This is a surprisingly easy thing to do. Good planning and early preparation reduces stress and provides for better performance. Good planning and early preparation also will allow for a good (or reasonable) night's sleep before an exam. This has shown to be a major requirement for good performance. Lack of sleep, all night cramming, inhibits performance - consistently.

SLEEP: Sleep is another important and intensely studied field of science. One of the effects of sleep is that it is the time we consolidate the memory traces stored in our brain over the course of the day. There is a small measurable and significant increase in the ability to recall or reconstruct when learning is followed by sleep. In both animals and humans, an increase in the amount of rapid-eye-movement (REM) sleep is observed during the night following a learning experience. Conversely, sleep deprivation inhibits learning (Stickgold, 2005; Wikipedia sleep web site, 2006[(4)]). The absolute worst thing you can do to prepare for an exam is to compress it all into the last 12 to 18 hours before the test, "pull an all nighter." This is an attempt to force as much information into short-term and poorly formed, seldom used memory and is not reliable. Often such students can recall a lot of facts but can do little with them. This information is soon lost. While "cramming" may "feel right," it is wrong as it relies on short-term memory and is unreliable and forgettable, so FORGETABOUTIT!

Plan your study so that you can get a good night's sleep before an exam. This means efficient studying throughout the course especially before the exams. It’s easier to keep up, than catch up!

During the exam: Look upon the exam as if it were another study session wherein you ask yourself questions and then answer them. Most of the time, you will already have dealt with the problems presented and it is simply a repetition. You do not have to take a test in the order that it is presented. Go through the test and answer all the questions that are easy for you. Then go back and do the questions that you have to think about, but that you feel relatively secure answering. This will guarantee that you receive points for everything you know AND it will build your confidence for tackling the question(s) that you have to really work on to answer. If you spend the first part of the exam panicking over what you don’t know, you will begin to doubt what you do know. Don’t fall into that trap. Concentrate and re-check your work when you are done. When the anxiety builds, when

you are uncertain--- that is the time to slow down not speed up to get it over. When the material is presented in an unfamiliar way, take a deep breath if it doesn't look familiar, slow down and rethink it. You have studied it and dealt with it in a different way. Using information in a novel way to solve a problem is part of training your brain to think differently, which is also part of a good college education. Approach the difficult questions the same way that you approached the test as a whole, start by writing what you know. You have to use what you know to answer a question or solve a problem that you haven't seen before and then reapply it in a different way. Remember no one is right all the time. Be challenged, be not afraid, or discouraged.

SUMMARY: Learning is a biological process that relies on the brain, a physiological organ that demands the same maintenance the rest of you does. Like a musical instrument the brain requires repetitive practice to "tune" it for maximum efficient performance. It requires study, discipline, and work and is ultimately rewarding. A good college education is one of the most thrilling experiences of life. Enjoy it, and know that the learning skills you gain will stay with you forever.

(1). "The Biology of Learning" was written by Dr. Stephen Londe for his students at Santa Monica College in 2006

(2). learning styles survey

(3). **The Brain: How Memory Works**

(4) **Sleep and Learning**

(5) **See Student Responses below!**

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SOME STUDENT RESPONSES TO "THE BIOLOGY OF LEARNING"

All Direct Quotes

I have been attending college for a year and a half and have not understood and learned so many important things I just learned out of reading an essay and a couple of articles. I learned the difference between reading and understanding and the importance it is to know that fact……

"The Biology of Learning" article opened my mind greatly on what it really means to learn and how much is really involved in what our brain takes in. To conclude I just want to point out how helpful this assignment was to me, both the article and survey helped me really see how to learn and what I can do to add to the strengths I have. It gave me perspective and helped me realize how complicated learning is and how our mind is affected by that. I can not ask more from an assignment and I was happy to be a part of it…..

Doing this assignment has helped me realize how valuable my learning experience is and how much it will help me out in the long run. I have now changed my thoughts about why I am in college from "because I have to" to "because I want to" and I am very happy I can say that……

Throughout my High school years i noticed that the public education system in America was getting something wrong. I didn't exactly knoow what it was, but I knew there was something just not right. It seemed as if they were not teaching correctly, because not only did the students not have any knowledge but they simply did not know how to attain knowledge. In other words, the education system was essentially leading them to use their brain in the wrong way. I now know exactly what it was that they were doing wrong. Instead of teaching kids to understand first and then memorize knowledge, they taught kids to forgo the step of understanding and simply memorize material. This created a situation in which students were simply not learning anything. By the time students got to the college level (if they even got to college) it was too late to change the way they think. The biology of learning should be taught from an early. Furthermore, the teqhniques of learning that follow from our understanding of the brain and how it learns should be used from an early age…..

In the beginning, I was not too thrilled about doing this assignment, it looked like a lot of reading and didn't seem to have all that much to do with biology. Now, I'm really glad we did. What I learned about how to learn is going to benefit me in all of my classes. All of the tips from the proper way to take notes, to the best methods of reviewing the information, not to mention the gentle reminder that I actually have to understand something in order to learn it (Londe) are real world useful tools that I should have had a long time ago….

It's official, the process of learning is no longer free. It can only be bought with the currency of willingness, repetitive elaboration, and discipline. In taking the learning style survey, I had discovered that my predilection of learning was auditory/kinesthetic. Before the survey, I had always approached studying incorrectly, hence, I suffered. I've changed my whole approach by employing a recording device during lectures and seeking out study groups.