A Fascinating approach to learn Biochemistry For Medical Students

Chamindri Witharana
Indika Karunathilake

A FASCINATING APPROACH TO LEARN BIOCHEMISTRY FOR MEDICAL STUDENTS

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Contents

Foreword

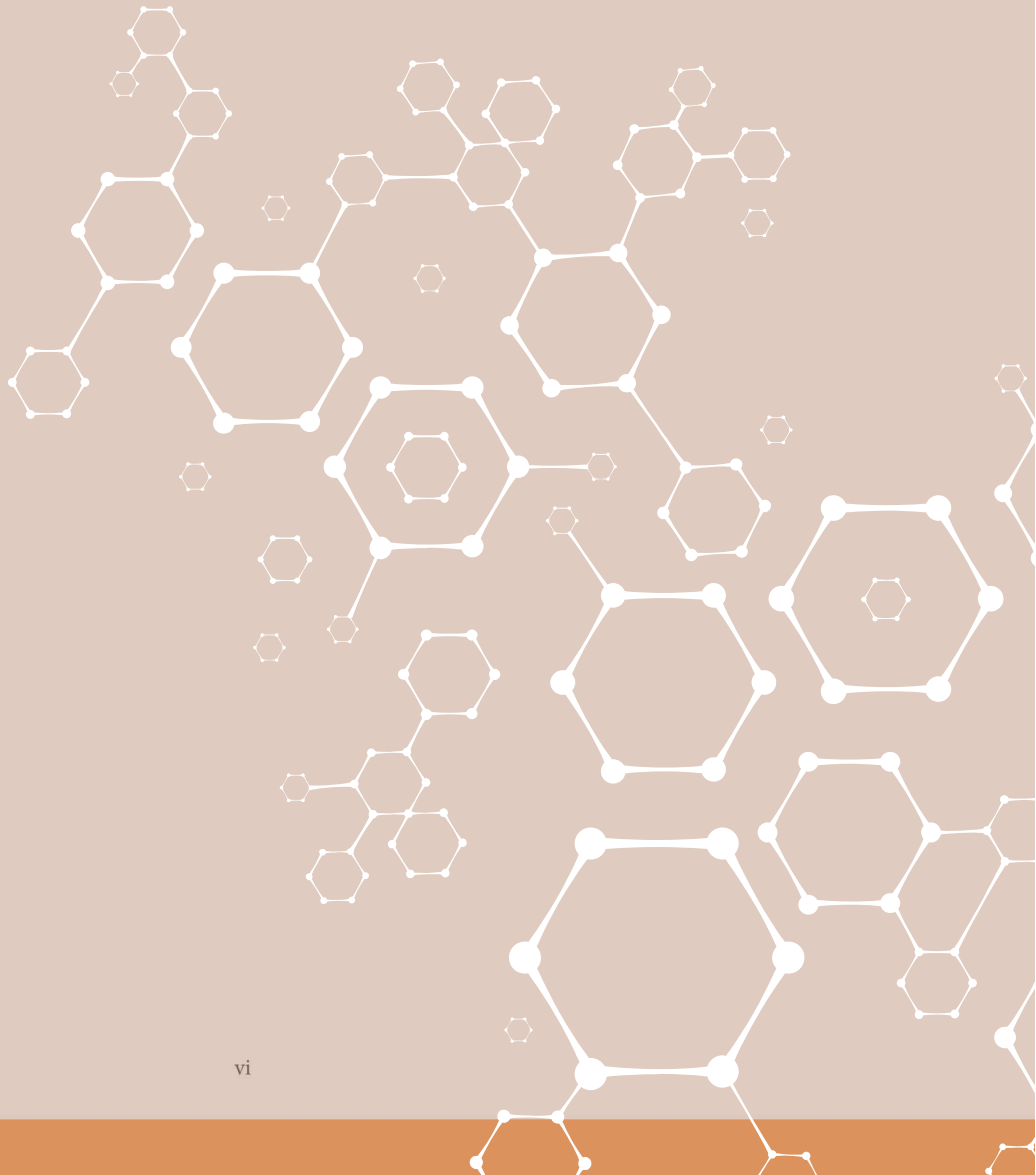
The complexity of learning Medicine keeps increasing with time, due to expansion of knowledge and novel changes in practice. This has led to increased content burden on students, with extensive information and details to memorise.

Biochemistry is one area where there is an extensive amount of information to process and memorise; so much so that it can take away student interest and fascination of the subject.

It may also cause the practically relevant information to get crowded by minutiae.

This booklet is an attempt to lessen the burden on students in memorising through different approaches to learning.

This does not replace any of the available or recommended text books and is thought of more as a study companion to make learning more enjoyable and effective; and not to cover course content or minor details.
Welcome to the fascinating world of Biochemistry!



What is learning?

Henry Ford once suggested that anyone who stops learning is old, whether at twenty or eighty and anyone who keeps learning stays young. Learning is a complex intellectual process that takes place during the whole span of life. What learning is and how learning occurs still remains a partly completed jigsaw puzzle. However, In order to gain some understanding of what is teaching and learning, we need to understand basic principles, theories and concepts of learning and their practical applications in the context of Biochemistry.

This book, illustrating fascinating aspects of learning Biochemistry, based on educational principles, it is arranged in following sections.

1. Different approaches in learning Biochemistry
2. How theories of learning can be applied learning Biochemistry
3. The applications of domains of learning
4. Different learning styles and approaches
5. Relate Biochemical and neurophysiological basis of learning to principles and applications of learning
6. Illustrate the integration of practice and theory in Biochemistry

Different approaches in learning Biochemistry

Learning has the potential to occur in many different situations, contexts and time points. There can be many different types of learning occurring simultaneously within an educational programme, i.e. Formal learning,
non-formal learning and informal learning.

Formal learning is pre-planned, structured and delivered by the institution. An example could be a lecture in Glycolysis or a tutorial on protein synthesis.

Figure 2.1: Formal Learning

Non-formal learning are student-led, self-directed activities based on their perceived learning needs. One of the best examples in the Faculty of Medicine is what is affectionately known among you as “bat classes”, which is an entirely student organized, peer-to-peer teaching system. For example, when some of the first year students fail their end of stream examination, the students who have excelled in the exam with classes altruistically and benevolently take up the role of teachers of Anatomy, Physiology and Biochemistry!

Figure 2.2: Informal Learning

The following table will help to understand the difference between formal and non-formal learning.

Table 2.1: Formal vs Non-formal Learning

Formal Learning	Non-Formal Learning
Planned & structured	Unplanned, evolving
Mostly Teacher-centred	Learner-centred
Enrolment by criteria	Self-initiated
External objectives	Self-determined objectives
Summative assessment	No assessment

Informal learning is what inadvertently occurs while students interact with their colleagues. For example, you may experience a cramp while during a sports activity in the university ground. As students following Biochemistry, you will be able to link this phenomena with lactic acid formation in muscle during anaerobic respiration.

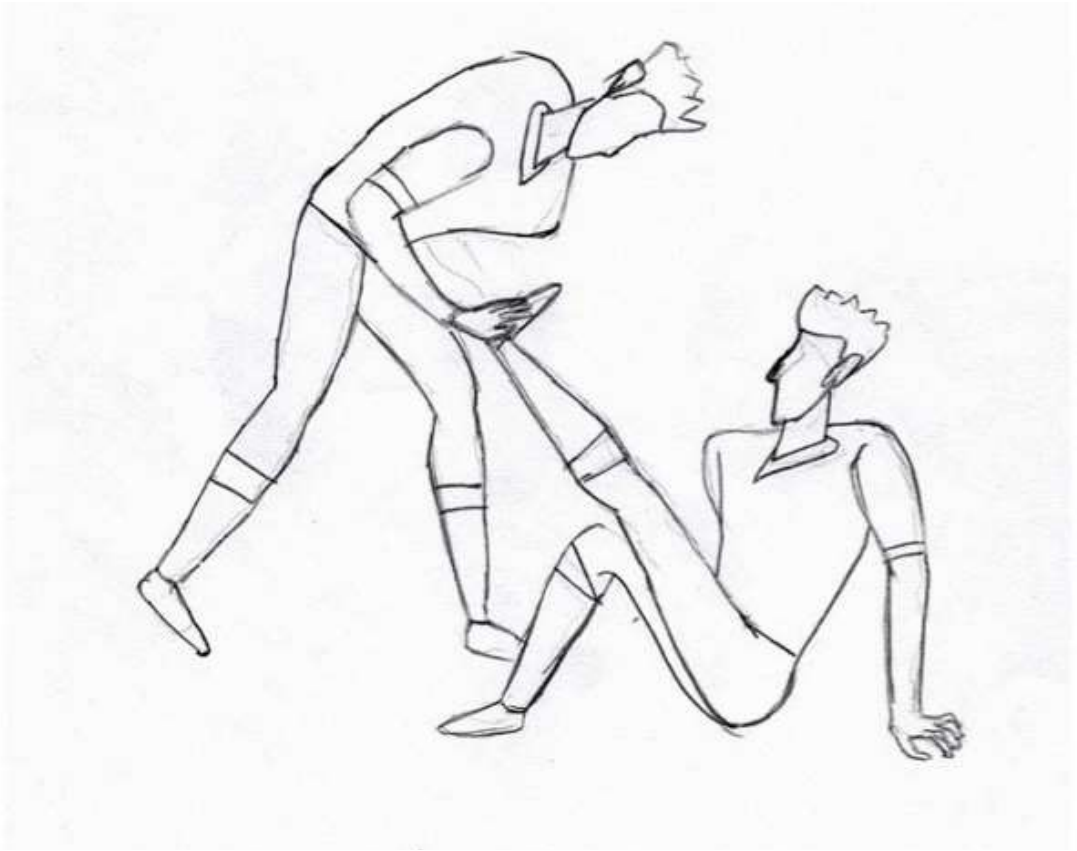


Figure 2.3: Informal Learning can happen in any setting!

The following table will help to understand the difference between formal and non-formal learning.

Table 2.2: Formal vs informal Learning

Formal Learning	Informal Learning
Measurable outcomes	Outcomes not measurable
High status	Low status
Prerequisite	No-prerequisite
Predominantly individual	Predominantly communal
Fixed & limited time-frame	Open-ended engagement

How theories of learning can be applied learning Biochemistry?

Over many decades, educationists, scientists and psychologists have tried to solve the mystery of how learning occurs. The key theories that explain learning are Behaviourism, constructivism and cognitivism.

Behaviorism

Behaviorist theory is the earliest attempt to explain how learning occurs. It argues that learning is a change of behavior that occurs due to experience. This theory was built on pioneering work of two scientists. Nobel price winning Russian Physiologist Ivan Pavlov (1927), who conducted his famous study on the response of a dog (salivation) when given a stimulus (food) concluded that repeated stimuli leads to a change of behavior. The relevant learning point in this for you as students is the importance of hands-on experience during practical classes.

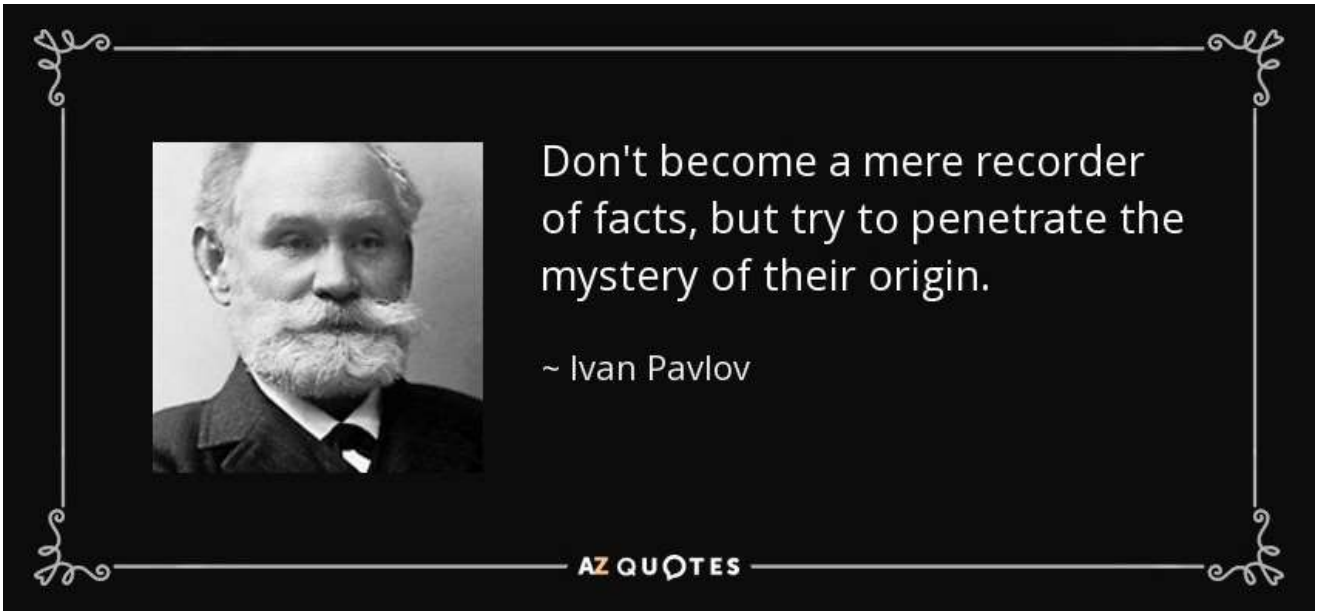


Figure 3.1: Ivan Pavlov (1849-1936)

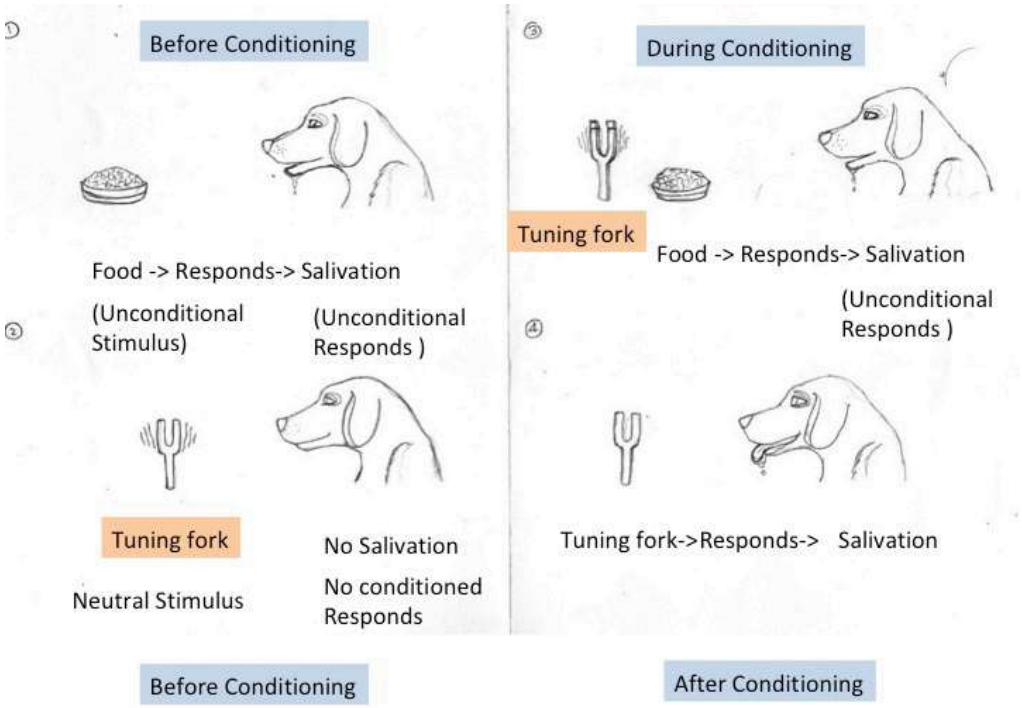


Figure 3.2: Ivan Pavlov' Study on Stimulus and Response

In 1938 Skinner studied how the behavior of rats changed when rewards and punishments were repeatedly given depending on their actions.

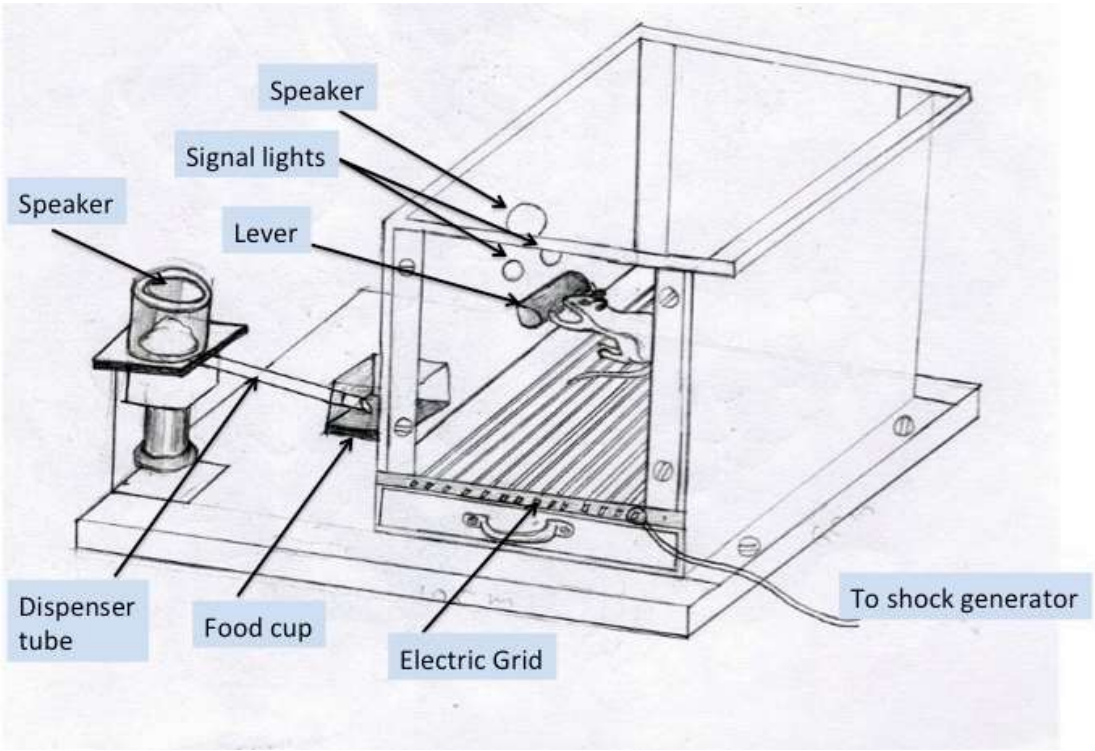


Figure 3.3: Skinner's study on Rewards and Punishment

For example, some students may be motivated to learn Biochemistry and rewarded with medals and distinctions.

Cognitvism

Behaviorism falls short of explaining the thinking process and how problem solving occurs in learning. Cognitivism attempts to explain this phenomenon. Cognitivism is based on meaningful learning and structuring of knowledge. Making learning meaningful is of utmost importance in Biochemistry, a subject where the practical relevance need be emphasized to the students as compared to a clinical discipline.

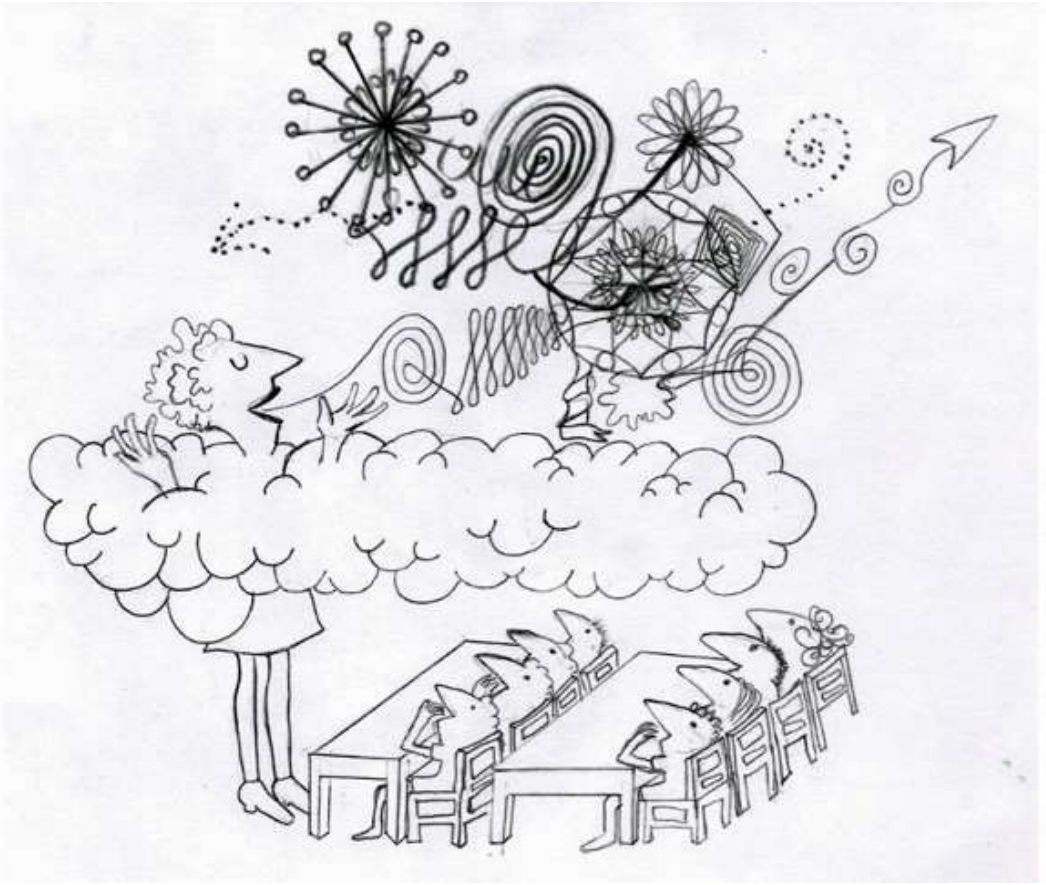


Figure 3.4: Concepts and facts that are fascinating to experts us may not make sense to students

For example, the Kreb's cycle of cellular respiration may not be meaningful for medical students unless you understand the relevance by relating to real life examples such as physical activities and exercise.

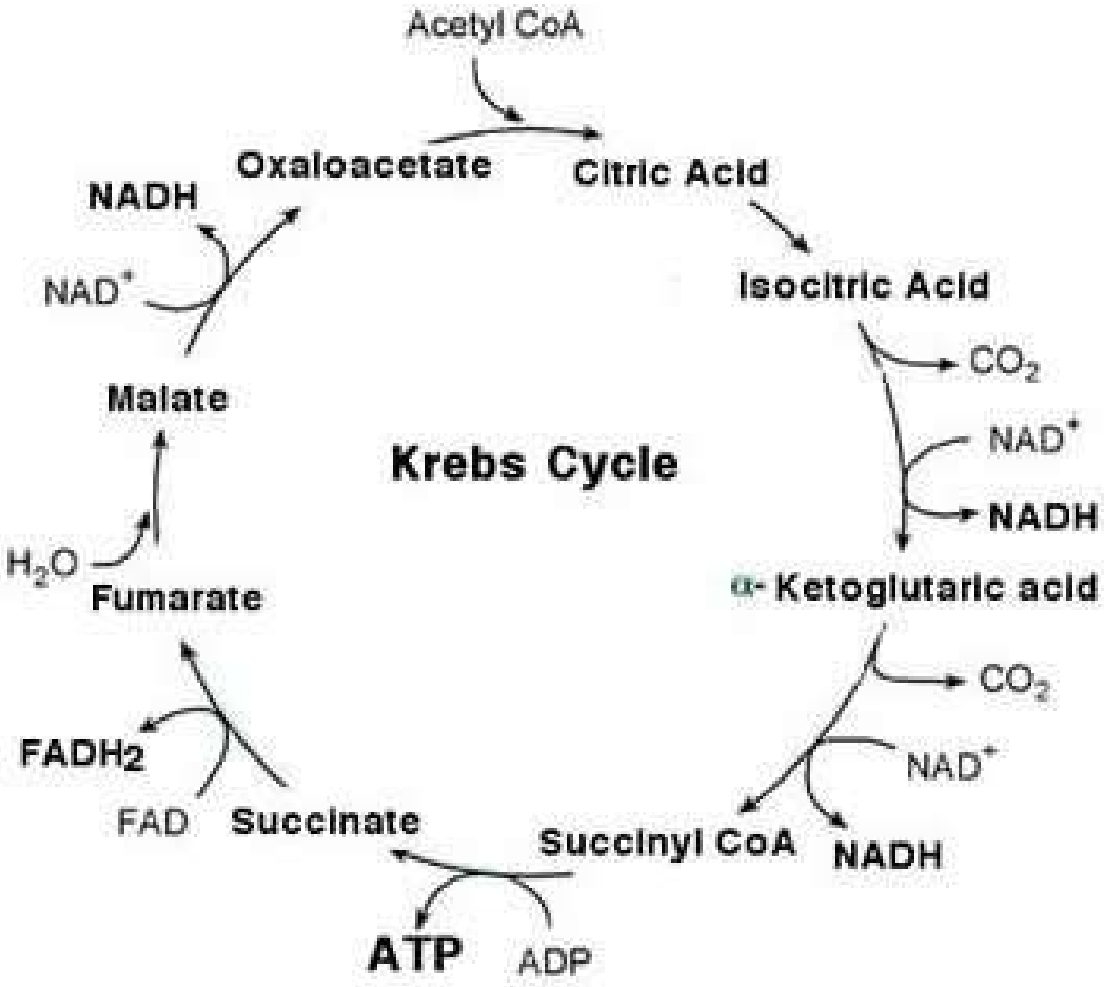


Figure 3.5: Kreb's Cycle

Structuring of knowledge forms the basis of successful learning. Chunking of information and mnemonics too are recommended for effective structuring of knowledge. For example, following simple mnemonic may help to reduce the burden of remembering the Kreb's cycle.

"Citrate Is Kreb's Starting Substrate For Making Oxaloacetate" (Citrate, Isocitrate, Ketoglutarate, Succinyl-CoA, Succinate, Fumarate, Malate, Oxaloacetate).

In chunking, isolated pieces of information are categorised together, so that the number of items to be stored in memory is less. For example the following mnemonic chunks the essential amino acids into three easy to remember categories.

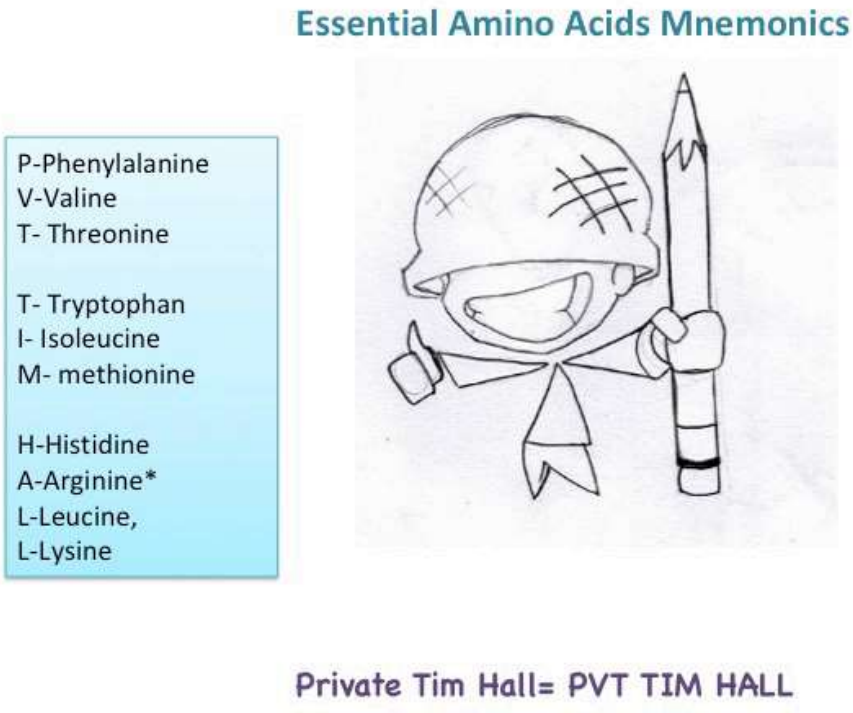


Figure 3.6: An Example of Chunking

How a particular component of knowledge is structured within the learners mind is very much relevant to learning Biochemistry where different pieces of information have to be connected in a manner that makes meaning. For example when you study hyperlipidemia, you should be able to understand the links between patients lifestyle, behavior, pathophysiology and pharmacology with the biochemical basis facilitate clinical decision making. Problem-Based Learning is a good opportunity to understand how these links can be made related to a case scenario.

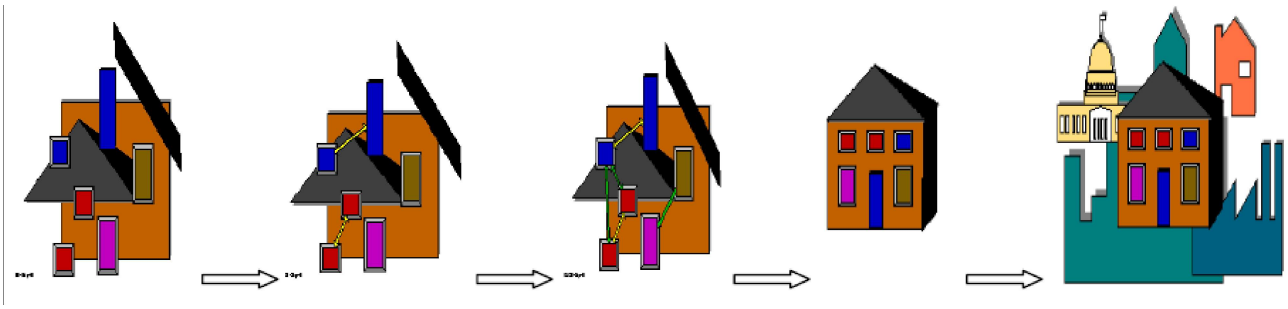
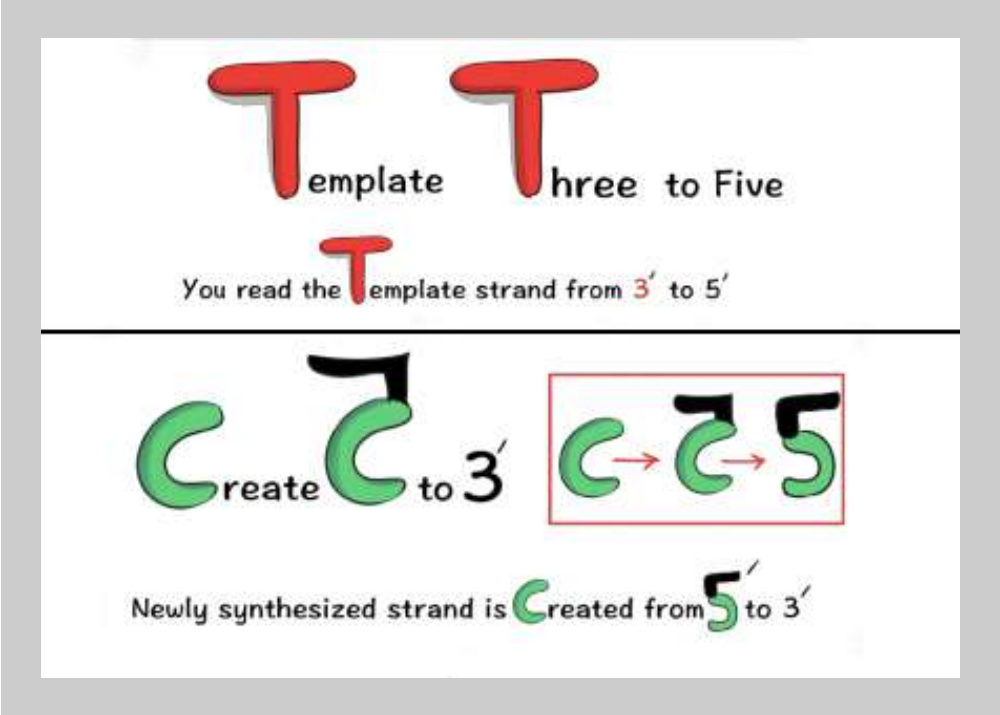


Figure 3.7: Students need to see the connection between isolated pieces of information and understand them in the context

Constructivism

In Biochemistry, you will be learning lot of new things. Constructivism explains how new learning occurs and constructed. As opposed to Behaviorist theory, which argues for rote learning, constructivism explained by Swiss psychologist Jean Piaget emphasis on understanding and analyzing. It argues that any new information given (short term memory) should be linked up with activation of prior knowledge (long term memory) for effective learning to occur.

For example, many areas that you have learnt during your GCE Advanced Level, such as cellular structure, DNA structure and biomolecules, will form the basis for more complex new knowledge.



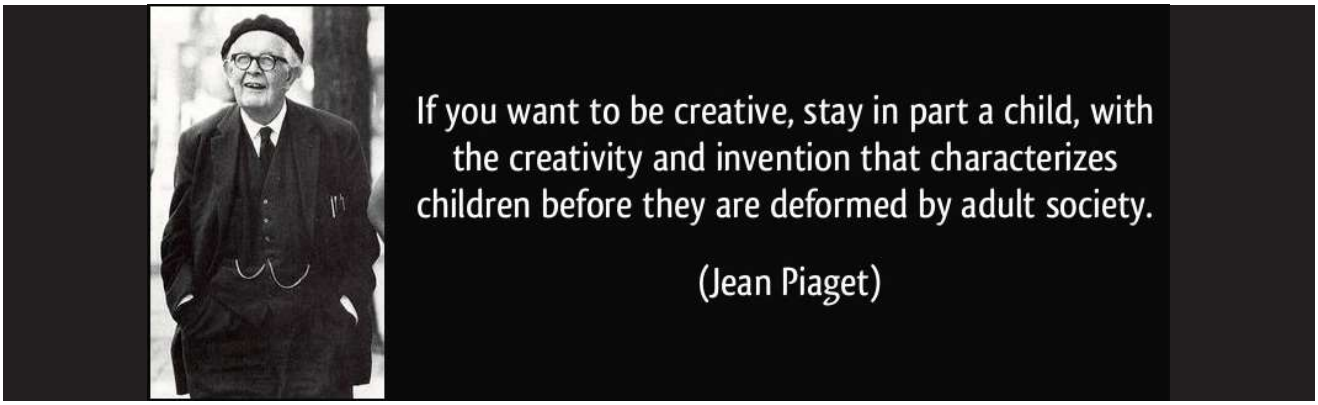


Figure 3.8: Jean Piaget (1895-1980)

Memory Process as Explained by Learning Theories

As students, you are always concerned about memory and retention of vast amounts of facts you have to learn. The theories of constructivism and cognitivism explain how the memory process works. The three main components of memory are sensory, short term and long term. For effective learning, knowledge should be transferred to long-term memory. The memory process has three stages; encoding (input of information and sensations), storage and retrieval of information.

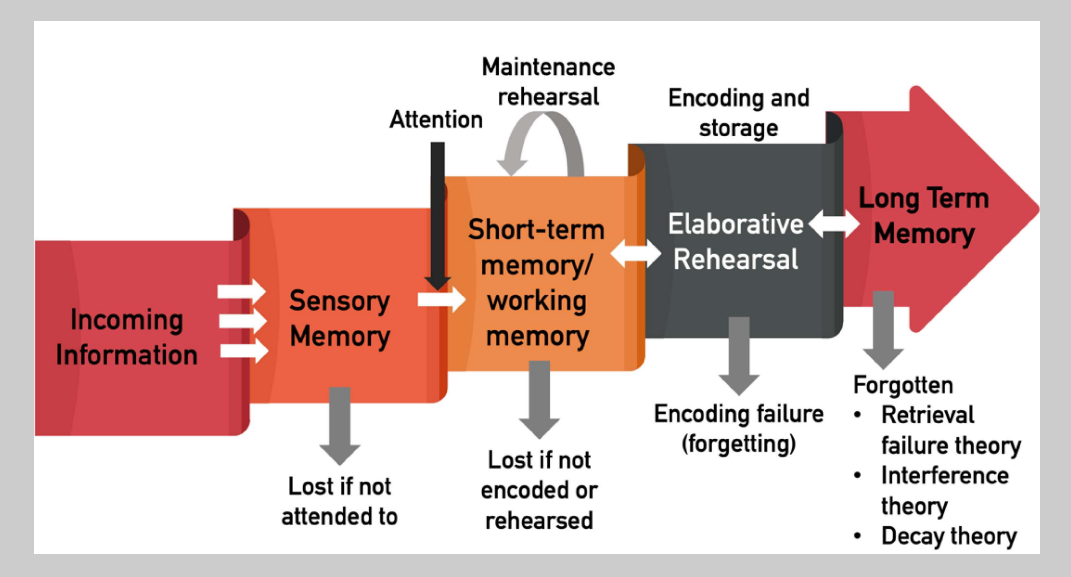


Figure 4.1: The Memory Process

In long-term memory, encoding occurs based on how the brain makes meaning of the information received (meaningful learning in Cognitivism) and activation of prior knowledge (Constructivitism). The effective storage of information depends on how the knowledge received is categorized and structured (chunking and mnemonics). The retrieval of information will be more efficient and swift in an environment and context similar to it was received. For example, what was taught in the Biochemistry laboratory would be more easily retrieved in a similar context later when you face your practical examinations.

Understanding learning objectives and outcomes

"If you don't know where you are going, it doesn't matter where you go"
Cat in Alice In Wonderland

It is important for students to understand the objectives and outcomes that are given to them. Specific learning objectives define what successful graduates should be able to do in very specific measurable terms of knowledge, skills and attitudes. Expanding on this principle, in 1950's Benjamin Bloom and coworkers identified three domains for learning, i.e knowledge skills and attitudes. For each of these domains, a hierarchical arrangement of levels of learning was identified (Taxonomy). For each level, series of action verbs (e.g. List, Discuss) that describe the level of learning were identified. Clear understanding of these action verbs and key words are essential for learning as well as succeeding in examinations, for, they specify what is expected from the students.

Knowledge Domain

The levels of learning in the knowledge domain of Blooms' taxonomy are as follows;

- Knowledge (Exhibits previously learned material by recalling facts)
- Comprehension (Demonstrating understanding of facts and ideas)
- Application (Solving problems by applying acquired knowledge)
- Analysis (Examining and breaking information into parts to make inferences)
- Synthesis (Compiling/ combining information together which leads to a solution)
- Evaluation (Comparing different options available and making judgments)

This concept may be illustrated in Biochemistry as follows, i.e. Lipid Disorders. Describing the lipid metabolism falls under the Knowledge. Classification of lipid disorders (e.g. Type I and II Hyperlipidaemia) is at Comprehension level. Identifying the causes (e.g. diet, lifestyle) for a particular disorder in a given case scenario is Application of knowledge. Interpretation the results of a lipid profile is at Analysis level. At Synthesis level, students will be able to develop a plan of management for a patient with a lipid disorder. At the highest level in the Cognitive domain (Evaluation), students will be comparing and contrasting different management options to make decisions.

Table 6.1: Levels and Action Verbs of the Cognitive Domain

Level	Action Verbs
Knowledge	Who, What, Where, Which, List, Name, Recall, Define, Label, Relate, State
Comprehension	Explain, Illustrate, Outline, Rephrase, Summarize, Show, Classify, Locate, Describe, Identify
Application	Apply, Build, Develop, Make use of, Organize, Plan, Select, Identify, Interpret, Construct, Demonstrate, Practice, Schedule, Sketch, Solve
Analysis	Analyze, Categorize, Classify, Contrast, Simplify, Inference, Conclusion, Compose, Distinguish, Appraise, Compare, Contrast, Separate
Synthesis	Build, Combine, Compose, Construct, Create, Design, Develop, Estimate, Formulate, Plan, Discuss, Modify, Change, Improve, Change.
Evaluation	Conclude, Criticize, Decide, Defend, Determine, Dispute, Evaluate, Judge, Justify, Compare, Rate, Recommend, Interpret, Appraise, Prioritize, Opinion, Prove, Assess, Estimate, Deduct

Attitudinal Domain

Example of different levels of attitudinal domain are; Awareness –Students are aware of ethical behavior and good attitudes

- Responding-Students comply with acceptable ethical norms and behaviours
- Value-Students demonstrate sensitivity towards ethics and attitudes
- Organization-Can prioritize different contrasting values
- Internalizing- Displays a professional commitment to ethical practice

Table 7.1:

Level	Action Verbs
Awareness	Asks, Chooses, Describes, Identifies, Follows, Points to, Selects, Names, Acknowledge, Attend
Responding	Answers, Assists, Contributes, Complies, Conforms, Discusses, Greets, Presents, Reports
Value	Demonstrates, Differentiates, Explains, Justifies, Proposes, Argue, Challenge, Debate, Refute, Confront, Criticize, Completes, Shares
Organization	Adheres, Alters, Arranges, Combines, Compares, Defends, Explains, Formulates, Identifies, Relates, Modify, Prioritize, Contrast, Synthesizes
Internalizing	Acts, Discriminates, Displays, Influences, Modifies, Performs, Practices, Questions, Revises, Serves, Verifies, Solves

"To educate a man in mind and not in morals is to educate a menace to society" Theodore Roosevelt

Skills Domain

The six levels of skills domain are as follows;

- Perception- The ability to identify using senses (e.g see, listen, feel)
- Readiness to act- Explain or demonstrate a sequence of steps in a process
- Guided Response-Can perform under supervision
- Mechanism- the activity/task can be performed with some confidence and proficiency
- Adaptation- Skills are well developed and the individual can modify actions to fit special requirements
- Origination- Creating new methods to act in a particular difficult situation

Table 8.1: Levels and Action Verbs of the Psychomotor Domain

Level	Action Verbs
Perception	Chooses, Describes, Distinguishes, Identifies, Isolates, Selects
Readiness to act	Assemble, Demonstrate, Displays, Explains, Proceeds, Shows, States
Guided Response	Performs, Attempts, Initiate, Reproduce
Mechanism	Assembles, Displays, Measures, Mixes, Organizes
Adaptation	Adapts, Alters, Modify, Revise, Changes, Rearranges
Origination	Arranges, Combines, Creates, Designs, Initiate, Originates

Above key words and levels can be illustrated based on the practical sessions on Thin Layer Chromatography (TLC). TLC is a complex procedure involving a series of chemical interactions.

Showing only the final product means that the practical is at the lowest level of psychomotor domain (perception). In order to move to the next level, which is the readiness to act, we need to show the intermediate steps of the process. Furthermore, it is necessary to show the relevance and application of this process to the students. With regards to this practical, readiness to act, which is the level two of the psychomotor domain is the highest milestone appropriate at the undergraduate level.

Another example is gel electrophoresis.

The gel, end product of the gel electrophoresis could be shown to the students (perception)

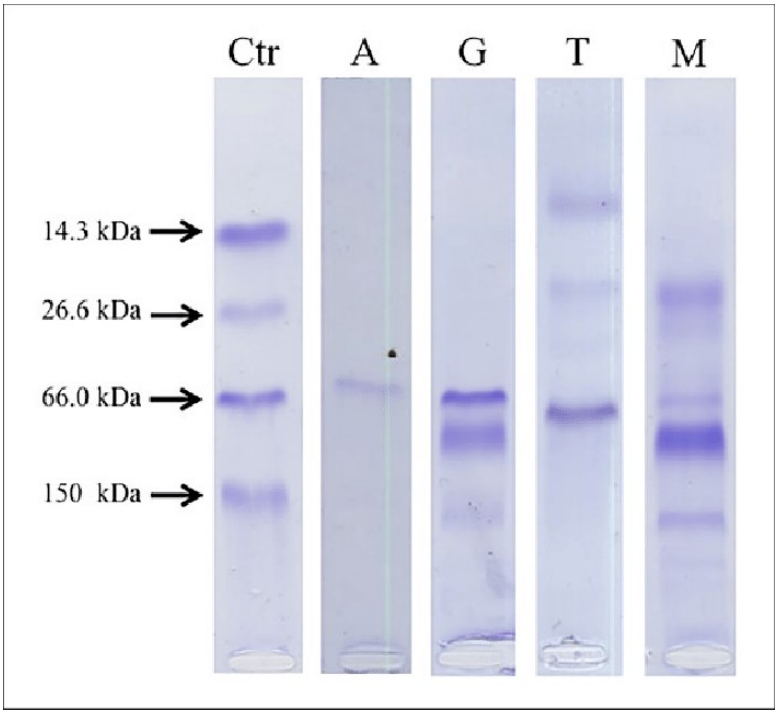


Figure 8.1: Agorose gel

Readiness to act- the intermediate steps are shown : how the gel is formed, samples and the DNA ladder is loaded to the gel, voltage application and the result.

In a guided responds, the student is allowed to prepare an agorose gel and load the samples to the wells.

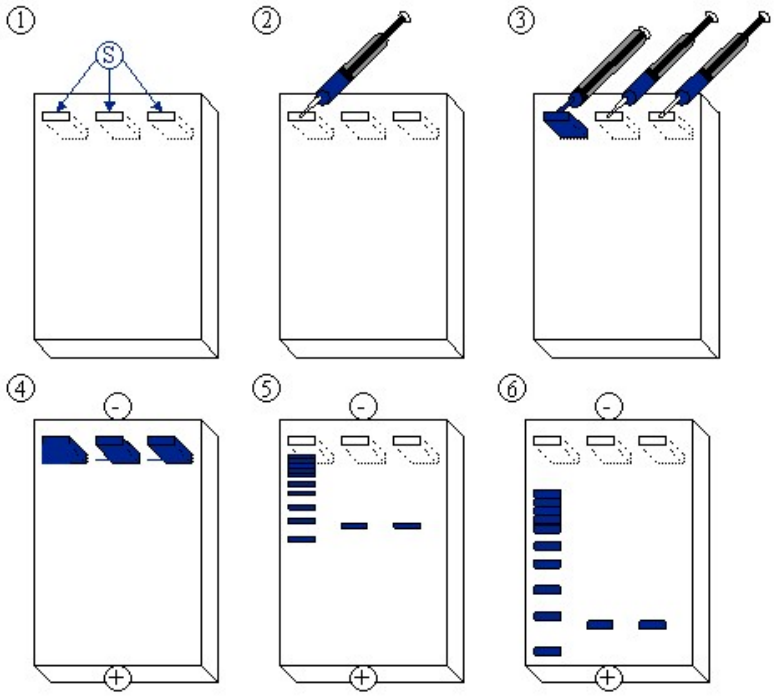


Figure 8.2: Agorose gel electrophoresis

How to follow a teaching activity effectively?

Main events of a teaching activity include;

1. Gaining attention
2. Providing learning objectives
3. Stimulating recall of prior learning
4. Provide learning guidance
5. Eliciting the performance
6. Providing feedback
7. Assessing the performance
8. .Enhancing retention and transfer

1. Gaining attention

For maximum efficiency, you need give your maximum attention to the lesson. Activities such as narrating a story, telling a joke, citing personal anecdote, showing a video or an image are purposely included into a lesson to gain the attention of students.

Providing learning Objectives/outcomes
Understand the learning objectives and focus on the action verbs. Learning objectives will tell you what the learners should be able to do at the end of the lesson. Given below is an example for a lecture on

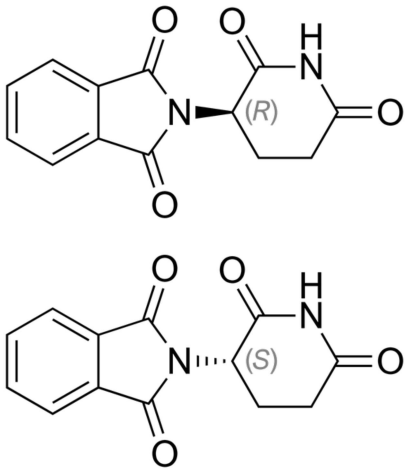
GLYCOLYSIS

At the end of the lecture the student should be able to ;

- Recognize that glucose metabolism via glycolysis is a fundamental pathway that is evolutionarily conserved
- Describe the energetics of glucose oxidation under aerobic and anaerobic conditions.
- Explain the enterohepatic circulation and where glucose enters when leaving the enterocyte

2. Stimulating recall of prior learning

Revise what you have learnt before related to the topic. This facilitates transfer of new knowledge into long-term memory. For example, you can revise what you have leant about DNA during your A/Ls before the lecture on Nucleic acids.



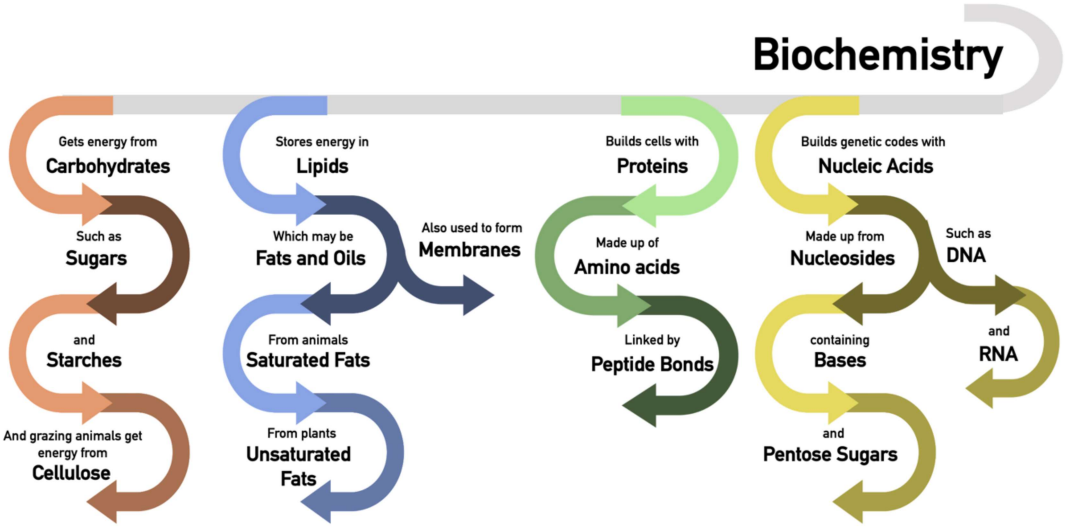


Figure 9.1 : Recalling using mind maps

3. Provide learning guidance

Be alert for the learning guidance and clues provided by the lecturer. Learning guidance is provided to ensure that knowledge is structured in appropriate manner and transfer to long-term memory is facilitated. For example, lecturer will provide an analogy, illustration, a map or a chart, which give students a framework that guides them. Similarly, a lecture could be started by giving a two-minute summery of what was covered in the last lesson and finishing by outlining what will come next (last week...next week).

4. Eliciting the performance

Eliciting the performance is essential during practical classes. Sometimes lecturers will ask questions during a class to ensure that students have clearly understood the content. Take it as a positive advantage.

5. Providing Feedback

Constructive feedback is essential for improvement. Lecturers will use this strategy during the Biochemistry practical sessions where students make errors very frequently. E.g. “You have done well to use the appropriate reagents. However, you need to measure and use the correct amounts of the reagents to get the expected result” , and ending with an encouraging remark.

6. Assessing the performance

Assessment of performance is essential for practical teaching. Biochemistry is a subject, which has lot of practical training. Formative assessments are incorporated into practical sessions with this purpose.

7. Enhancing retention and transfer

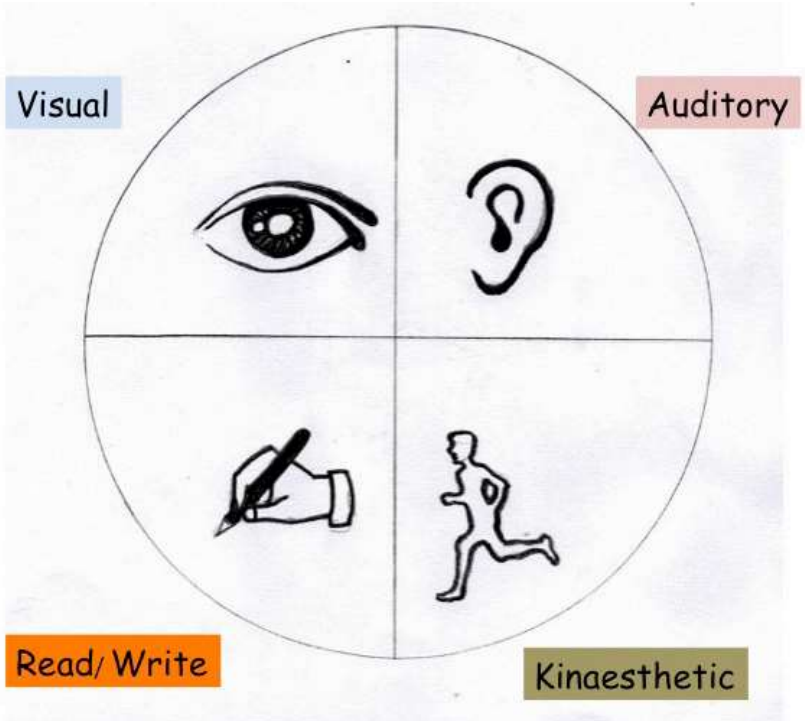
Repeated practice will enhance retention. For example, the practical session on abnormal constitutions in urine, followed by a formative assessment (Enhance retention). In the final year, the students do the similar practical during the clinical appointments (transfer to real life practice).

Learning Styles

Learning styles may be defined as how a learner perceives, interacts with and responds to the learning environment. The learning styles of different students vary widely.

Learners could be cateogrised according to their preferred sensory modality for learning. Visual learners

1. Auditory learners
2. Read/write learners
3. Kinesthetic learner



Approaches to Learning

Learning styles and approaches to learning are interconnected. Approaches to learning are broadly categorized as superficial and deep learning.

Assessment methods that create anxiety and that emphasize recall or application of trivial knowledge and fear of failure, an excessive amount of material in the curriculum in the form of inert, discrete knowledge as facts, poor or absent feedback on progress and lack of interest in the subject matter leads to superficial learning.

Therefore, the motivation in superficial learning is extrinsic. In contrast, deep learning is based on intrinsic motivation. Deep learning is promoted through applying knowledge. In Biochemistry, a subject with large amounts of facts to be learned, we should always promote application of knowledge.

Active Learning

"Tell me, I'll forget, Show me, I'll remember, Involve me, I'll understand"
Chinese Proverb

In active learning, the student is meaningfully engaged in the learning process. Active learning leads to better understanding and retention of knowledge. The learning pyramid shown below illustrates how incorporation of active learning leads to higher retention.

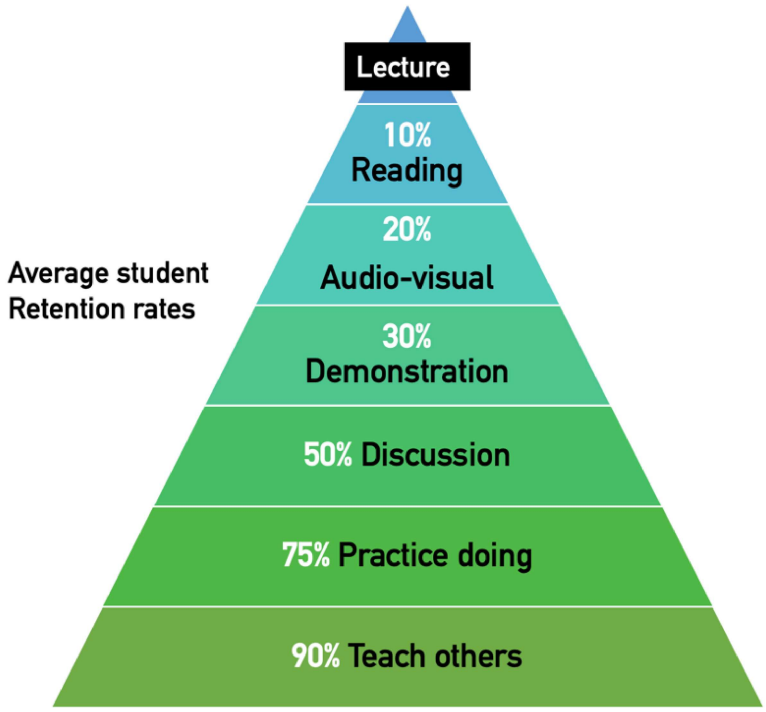


Figure 12.1: Learning Pyramid

"Give a man a fish and you feed him for a day; teach a man to fish and you feed him for a lifetime" Maimonides

Adult Learning Theory

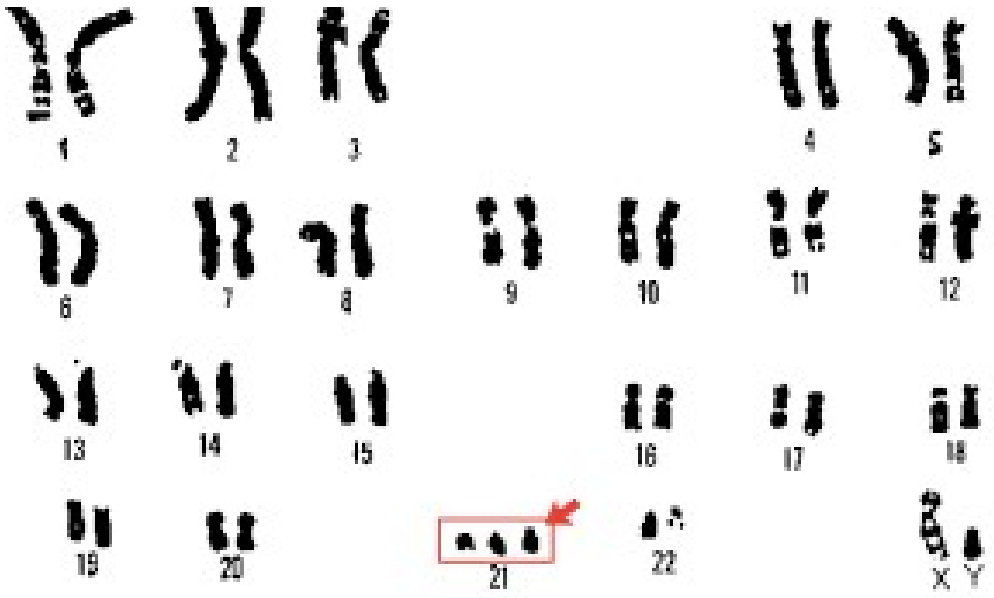
How adults learn can be linked to deep approach to learning and active learning. In the Faculty of Medicine are adult learners. Adults, as learners,

- Have a “need to know why” they should learn something
- Are self-directed and autonomous
- Bring in a wealth of experience to a learning session
- Will learn if it uplifts their current levels of standards
- Prefer to learn if it is linked with their current tasks

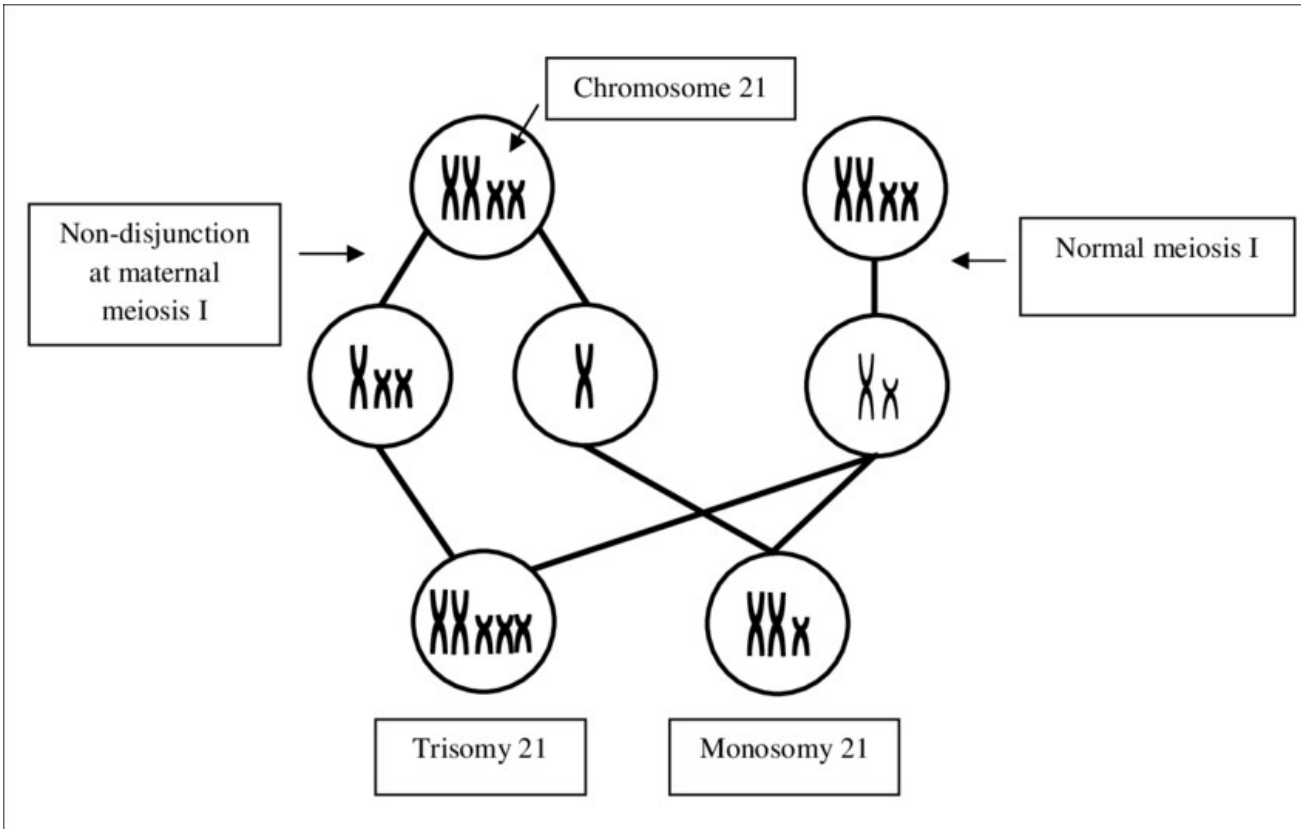
Therefore, as students, we always need to understand the practical relevance of subject matter.

For example when learning genetic mutations following example from clinical conditions such as Down’s syndrome can be used.

Karyotype: The number and visual appearance of the chromosomes in the cell.



The reason for the 21 chromosome trisomy : Trisomy 21 is the cause of approximately 95% of observed Down syndrome, with 88% coming from nondisjunction in the maternal gamete and 8% coming from nondisjunction in the paternal gamete.



Phenotypic features of downs syndrome:

Student Assessment

"The curriculum instructs teachers what to teach;
the exam instructs students what to learn"
- Donald Melnik, 1991 -

Facing examinations is part of life of a medical student. Assessment becomes more prominent in an undergraduate degree programme such as Medicine where stakes are very high.

Assessment varies with their purpose. There are a multitude of reasons why assessment is important. These include;

- To make pass or fail decisions
- Grade and rank students
- To certify the achievement of competencies
- To provide feedback to students so they can learn from mistakes and build on achievements.
- To motivate the students learning and focus their sense of achievements.

Therefore, an assessment designed to certify students' competence to practice as a doctor will be different from assessment method to monitor students' progress and provide feedback. Traditionally assessment has been described either as "formative" where the main objective is to provide feedback and as "summative", where marks are carried forward to make pass/fail decisions. The summative assessments are used to determine whether the learning outcomes have been successfully achieved. The student usually receives a grade or a mark which indicate the level of achievement. The final common MBBS examination which determines the merit order of medical graduates can be taken as an example for certifying and ranking assessment.

Assessment is a powerful motivator and a major driving force of learning. This factor could be utilized to motivate students and guide them.

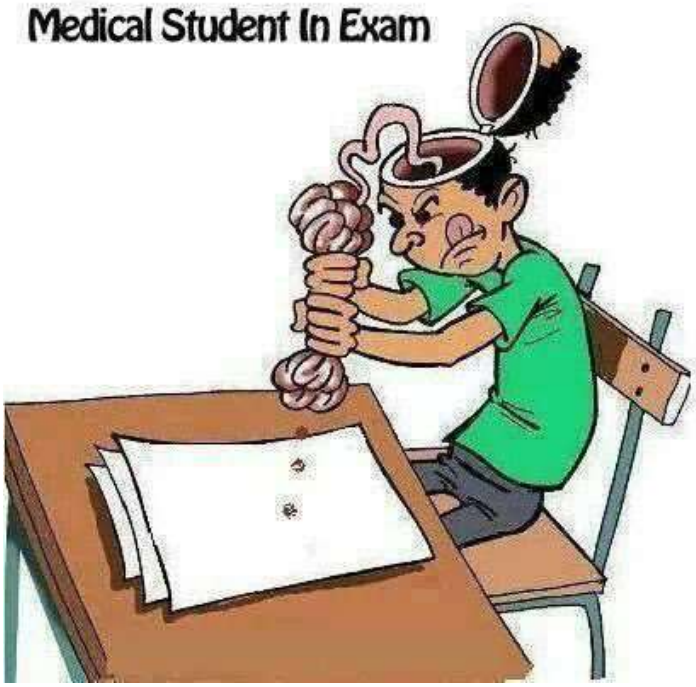


Figure 13.1: Assessment of Trivia Promoting Memorizing and Factual Recall.

What Should be Assessed?

An educational programme is defined by the exit learning outcomes that the students should achieve at the end of the programme. Therefore it makes sense that a good assessment system measures the students' progress towards and achievement of learning outcomes.

Exit learning outcomes define what the graduates should be able to do at the end of the degree programme. The exit learning outcomes of the Faculty of Medicine are;

1. Clinical skills
2. Patient management
3. Health promotion and disease prevention
4. Medico-legal Duties
5. Scientific basis of practice
6. Communication and interpersonal skills
7. Teamwork and leadership
8. Ethics and professionalism
9. Planning, critical thinking and analysis
10. Lifelong learning and CPD

"Assessment is the engine which drives students learning"

-Thomas Cowens(xxx)

Miller (1990) described a four-level pyramid that illustrates the levels of assessment to guide the selection of an appropriate assessment tool. The four levels of assessment described by Miller are, "knows", "knows how", "shows how" and "Does". Miller argues that for an assessment system to be acceptable, all four levels should be assessed.

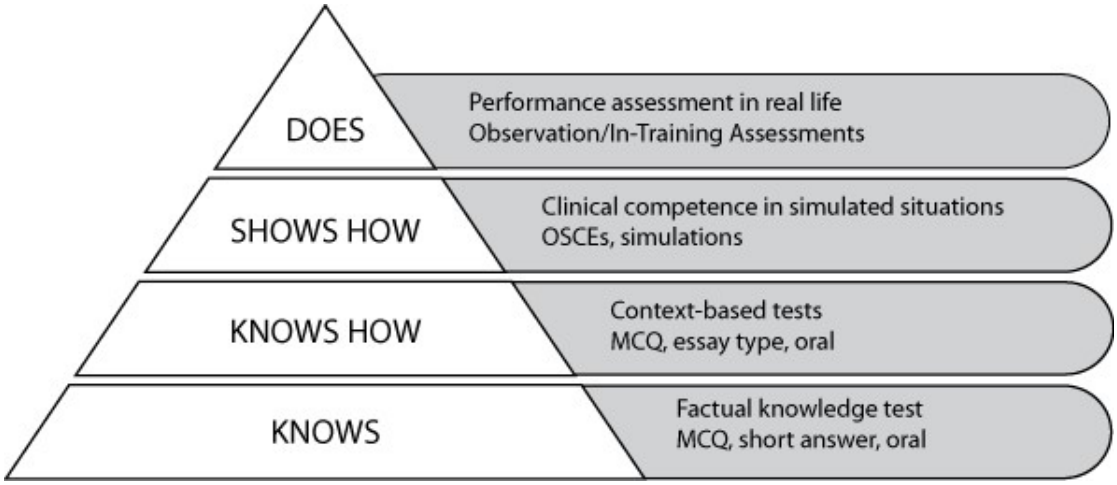


Figure 13.2: Miller's Pyramid of Assessment

"Knows" which is at the base of the pyramid indicates pure knowledge, acquisition and retention of facts. "Knows how" indicates cognitive ability to apply his/her knowledge. The next level named "shows how" assesses of whether the ability to demonstrate the required skills and the final level of "does" assess actual practice. The first two levels, which are domains of cognition, are primarily tested by written tests. The last two levels, which are domains of competence are tested by practical tests with the final level is assessed only through workplace-based assessments.

These levels of assessment may be illustrated using an example; i.e abnormal constitutions of urine.

1. Knows –Knowledge (Assessing if the student can list abnormal constitutions of urine. This may be assessed by a MCQ)

2. Knows how-Application of knowledge (Student can explain how abnormal constitutions are formed in urine. A Structured Essay Question may appropriately assess at this level.)

3. Shows how-In a practical test, student can demonstrate urine testing

4. Does-Student can perform the test in a real life situation such as bed side or the laboratory. This may be assessed by a supervisor using a rating scale.

Different Methods of Assessing students

A multitude of assessment tools are in practice, each with its own strengths and weaknesses. There is no single assessment tool that will assess all the outcomes and competencies. Some of the assessment tools frequently used in Biochemistry are Structured Essay Questions (SEQ), Multiple Choice Questions (True/False type) and Objective Structured Practical Examinations (OSPE) and practical tests.

Structured Essay Questions (SEQ)

SEQs are used in Continuous assessment tests in Biochemistry An SEQ are usually based on a case scenario, and include a series of questions which built from simple to complex. Each response should be scored against a rubric (marking scheme).

True-False (T/F) MCQs consist of statement for which the candidate has to indicate whether the given statement if true or false. The structure of a True/False MCQ includes a stem and five statements.

T/F MCQs are appropriate when a broad content area has to be samples. Therefore, this type of MCQs may be argued as suitable to test a content heavy subject as Biochemistry. However there are disadvantages in this format as well, including

mainly test at factual recall level, more chance for guessing, negative marking and difficult to construct flawlessly.

Objective Structured Clinical Examination (OSCE) was designed to improve the reliability of clinical assessment by increasing the objectivity and sample. There are many variants of OSCE. Objective Structured Practical Examination (OSPE) is designed to assess practical competencies mainly related to laboratory work. Similar to OSCE, OSPE is a performance-based assessment with multiple stations. At each station each student performs the same series of tasks such as identification, interpretation of investigations or performing a practical procedure/ test. Each station is marked using a standardized scoring system or a checklist.

Given below is a sample checklist to assess testing urine for sugar.

Score "1" for each point conducted correctly or mark "0" if the task is not done or incorrectly done and calculate the Score.

S.No	STEP / TASK	Score 1 / 0	Remarks
1	Take 5 ml of Benedict solution in a test-tube, Boil it over the spirit lamp, holding the test-tube away from your face.		
2	Add 8 drops of urine with the help of a dropper. Shake it well and boil.		
3	Allow it to cool and observe the color.		
4	Interpretations : Green precipitate : + Green liquid with yellow deposits : ++ Colorless liquid with orage deposits : +++ Brick red : ++++ or more sugar No precipitate : No sugar		
5	Discard the urine sample in the toilet.		
6	Decontaminate the urine container and test-tube in 0.5 % chlorine solution.		
7	Wash your hands thoroughly with soap and water.		
8	Explain & record result		

Pass Score = 07/08 (87.5%)

Student Score = _____

Pass- Yes No

Figure 13.3: Sample Checklist for an OSPE Station

Educational Impact

It is well known that assessment drives learning and any assessment should have a clear educational purpose and it must be designed to maximize learning in areas relevant to the curriculum. The methods of assessments used should strategically promote achievement of desirable learning outcomes.

I study
↓
I take the test
↓
I pass it
↓
I forget what I learnt

Figure 13.4: The Recall Type of Tests Lead to Negative Educational Impact

Acceptability

Acceptability refers to the extent to which stakeholders in the process endorse the results and their interpretation. These stakeholders include the medical students and faculty, practicing physicians as well as patients. Provision of information and willingness to compromise is important in increasing the acceptability of the assessment for all stakeholder. This will lead to higher face validity.

Cost-effectiveness

The cost-effectiveness of assessment reduces the gap between the information elicited and the resources required. The assessment process will have to be a compromise between utilizing the best possible assessment methods and the limited resources available to implement them. However, it is an investment as 'assessment drives learning'. For example conducting an OSCE is much more expensive in terms of the cost and resources than administering an MCQ paper. However, OSCE provides information on students practical competency which may not be obtained from a MCQ paper.

Biochemical and Neuro-Scientifc Basis of Learning

What would be the biochemical basis of learning? When reflecting? You will realize that in fact it plays a major role in learning, memory and cognition.

The basic building block of our nervous system is called a neuron. External information we receive via sensory inputs is transmitted to our brain through pathways and networks formed by neurons. The cell body of a single neuron will have multiple projections called dendrites that will connect with many other neurons. The gap between two neurons is called a synapse. Within a neuron, information travels as an electrical signal. Information is carried from one neuron to the next by biochemical messengers called neurotransmitters (e.g Acetylcholine)

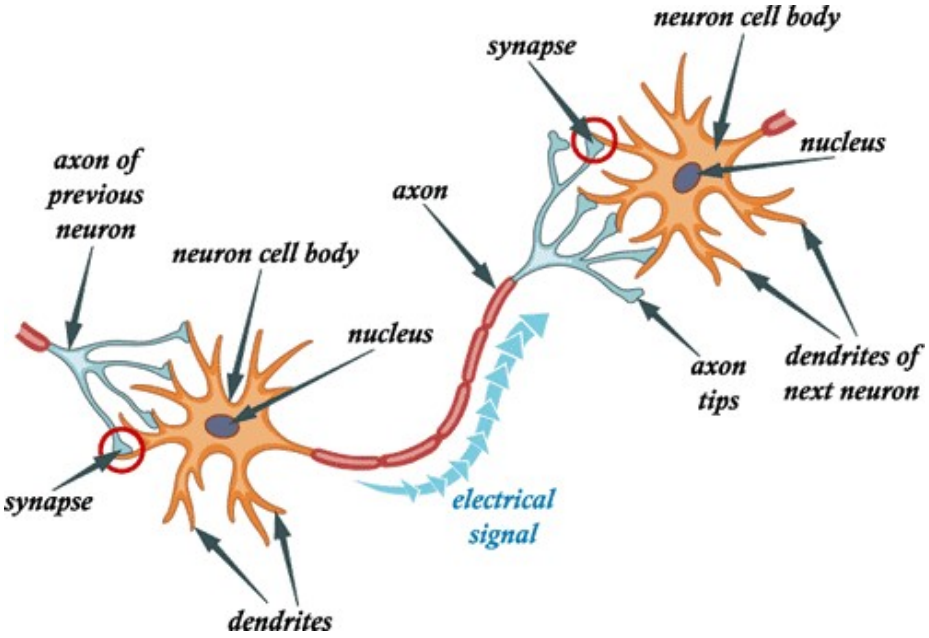


Figure 14.1: Structure of a Neuron and Synapses

The number of neurons doesn't increase after birth. So, how can we become better learners and performers with time? This could be explained by a multitude of biochemical and neuro-physiological factors.

When particular information is repeatedly and frequently transmitted, the relevant neuronal pathway becomes more established, more complexes connection are formed and the information is carried faster and swiftly. How does this happen?

Repeated transmission of impulses leads to increased production of biochemical neurotransmitters. The increased concentration of neurotransmitters stimulates formation of new dendrites, leading to more neuronal connection. Thus the neural pathway becomes broader forming a virtual information superhighway. Hence the greater the number of electrical impulses received and processed, the greater the amount of brain chemicals produced, the greater the network and the greater the memory.

This can be linked with the behaviourism which argues repeated practice leads to better performance. The multiple connections of neurons represent schema formation, i.e. how information is arranged in our memory (cognitivism).

Then, what is the link between emotions and learning? Our emotions and feelings originate in the limbic system in the brain (thalamus, hypothalamus, amygdala and pituitary). Limbic system is directly linked to emotions, pleasure, pain, and sensory perceptions. Also, it is where the previously mentioned neurotransmitters are produced. Therefore addressing the emotional component is important for effective teaching. The principle in humanism that both feelings and knowledge are important to the learning process can be supported by this fact. Use of stories, personal anecdotes, pictures and videos will facilitate desirable emotions among students, leading to activation of prior experiences (constructivism) and more effective learning.

"An understanding heart is everything in a teacher....One looks back with appreciation to the brilliant teachers, but with gratitude towards those that touched the human feeling" Carl Jung (1875-1961)

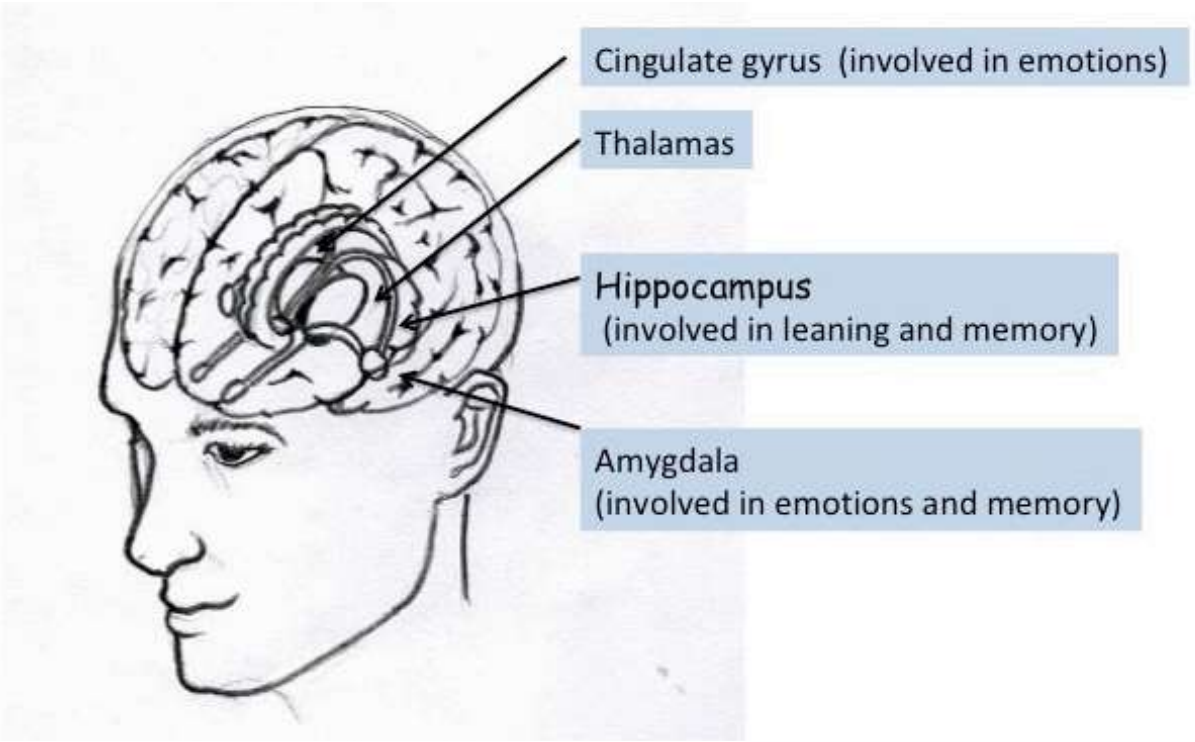


Figure 14.2: The Limbic System and Emotions

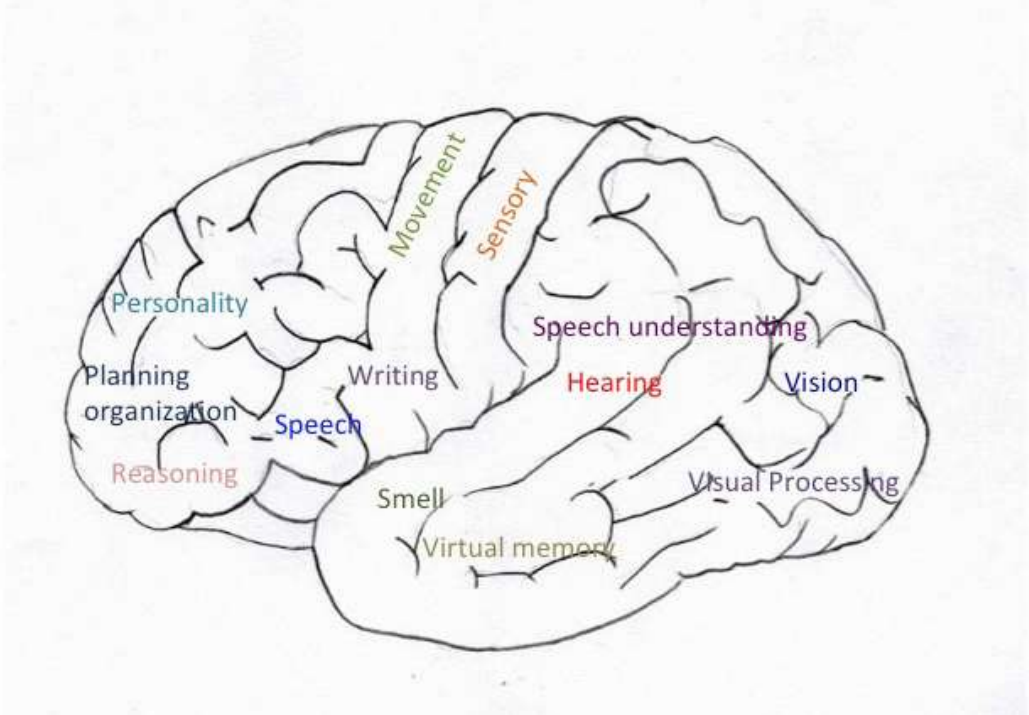


Figure 14.3: Functional Areas of the Brain

Therefore, what the learning theories, learning styles, biochemistry and neuro-physiology is that for effective teaching and learning, we need to stimulate as many areas in the brain (reasoning, visual, hearing, motor, sensory and emotional).

The theories of learning explain how learning occurs as a change of behavior, how cognition occurs though structuring of knowledge and schema formation and the memory process. Behaviorism has lead to the concept of learning domains and taxonomies. The existence of different learning styles and approaches highlight the diversity of our learners and the need to facilitate active learning. Biological basis of this complex and intertwined theories are illustrated beautifully though Biochemistry and Neurophysiogy!

"Education is not learning of facts..but training the mind to think"- Albert Einstein