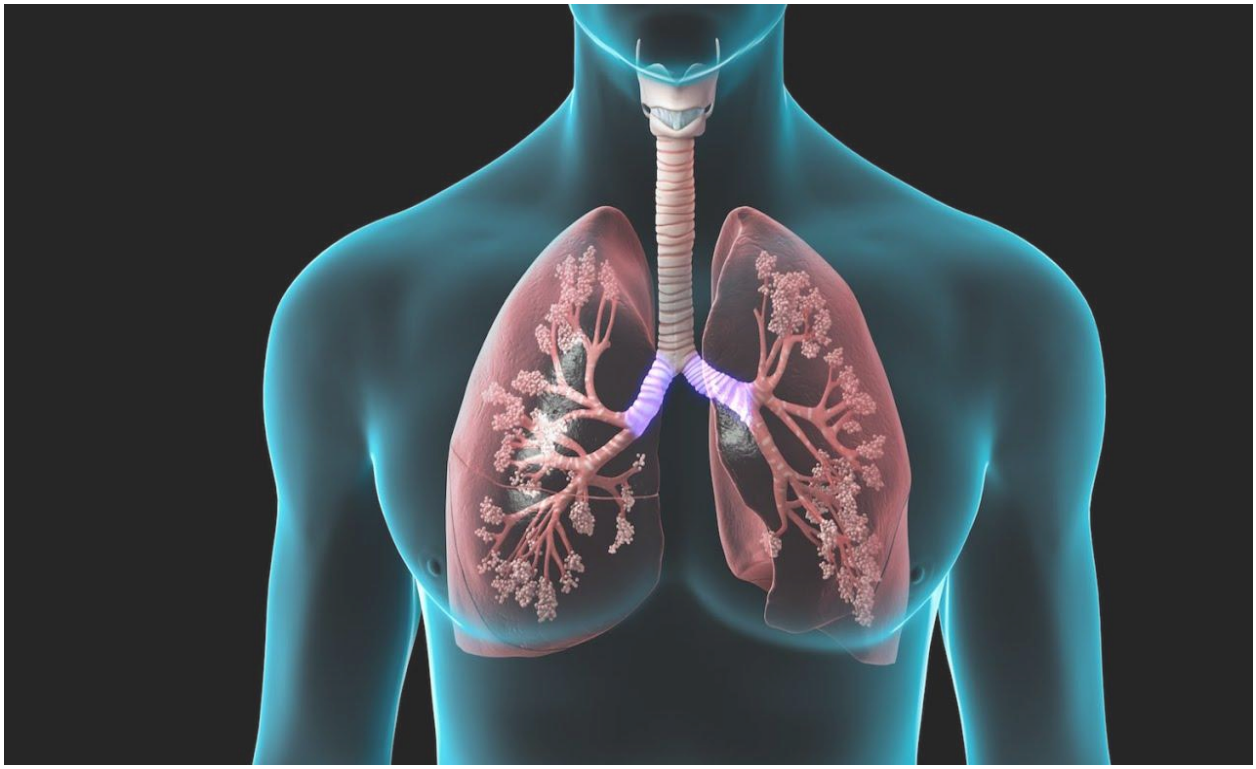
DESIGN PROJECT REPORT

- *Lower Respiratory System* -



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Foundations of Cognitive Sciences

INTRODUCTION

The lesson plan for the lower respiratory system is the second part of the respiratory system course, the sequel to the upper respiratory lesson. The intended audience is students from grades 10 to 12 enrolled in biology or anatomy courses with prior knowledge in the upper respiratory system. Our lesson design incorporates factual, conceptual, and procedural knowledge to create a media-rich learning environment, along with a hierarchically arranged knowledge structure, from which meaningful learning experiences are constructed. We aim to follow Bloom's Taxonomy, a framework to support teaching and learning. Among its many uses, it provides an excellent foundation for lessons, as it can be used as a framework in which to deliver appropriate activities, assessment, questioning, objectives, and outcomes to ensure students' progress is maximized. As Bloom's taxonomy is a hierarchy of progressive processes ranging from the simple to the complex, in which it is necessary for us, as the lesson designers to ensure students first master those lower down the pyramid before being able to master those higher up. In other words, by moving up the taxonomy, students become more knowledgeable, more skilled and develop an improved understanding of the respiratory system.

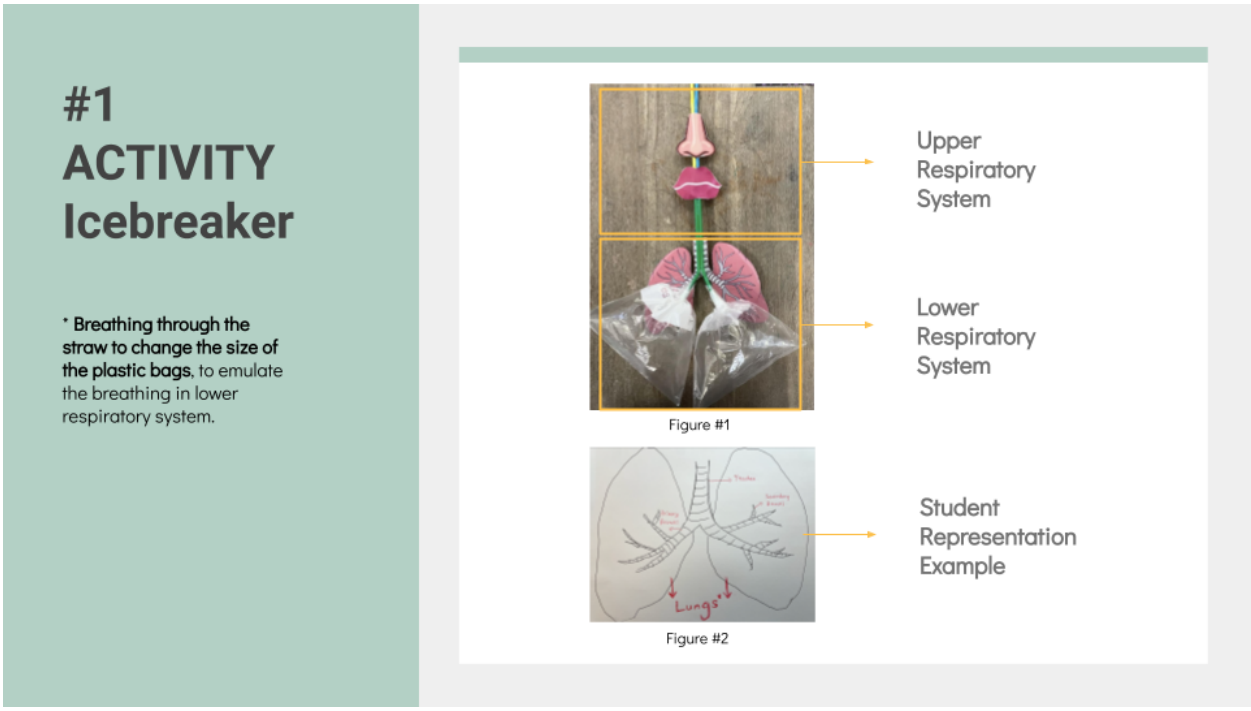
The major challenge in the current respiratory system course design is the inconsistency between the large amount of factual information that requires students to memorize and the limited cognitive capacity among students. Another pain point is that the biological knowledge might be too abstract for students to relate to real-world situations, and thus, result in low efficiency and low intrinsic motivation. Our following design document adopts advanced learning theories and strategies to create solutions to better communicate students with the abstract concepts and promote memorization with fewer efforts.

Please refer to this link for the PowerPoint version lesson plan:

https://docs.google.com/presentation/d/1zBoCcKLId_FfTM2hh0fg17V7elgZaE1l-_lzXTMaKcU/edit?usp=sharing

LESSON PLAN DETAILS

Section #1



Teacher's Memo

1. Teacher to explain the simulation to class with a concentration in showing the dividing line between upper and lower respiratory systems.
2. Teacher to guide the students to create general representations of the lower respiratory system, which students will bring home and make simulations with.
3. Teacher to simulate the breathing process in LRS by breathing in and out through the straws to change the size of the plastic bags.
4. Teacher to engage students with prompt questions to share their observations if time permits (optional).

This is a fun and engaging hands-on activity for students to observe the correlation between breathing and lung capacity, as well as visualize the main components of the lungs. Due to Covid-19, only the instructor will demonstrate the installation by emulating breathing through the straws to change the volume of the plastic bags. But the students will be prompted to make a representation of the lung structure and make the installation by themselves at home.

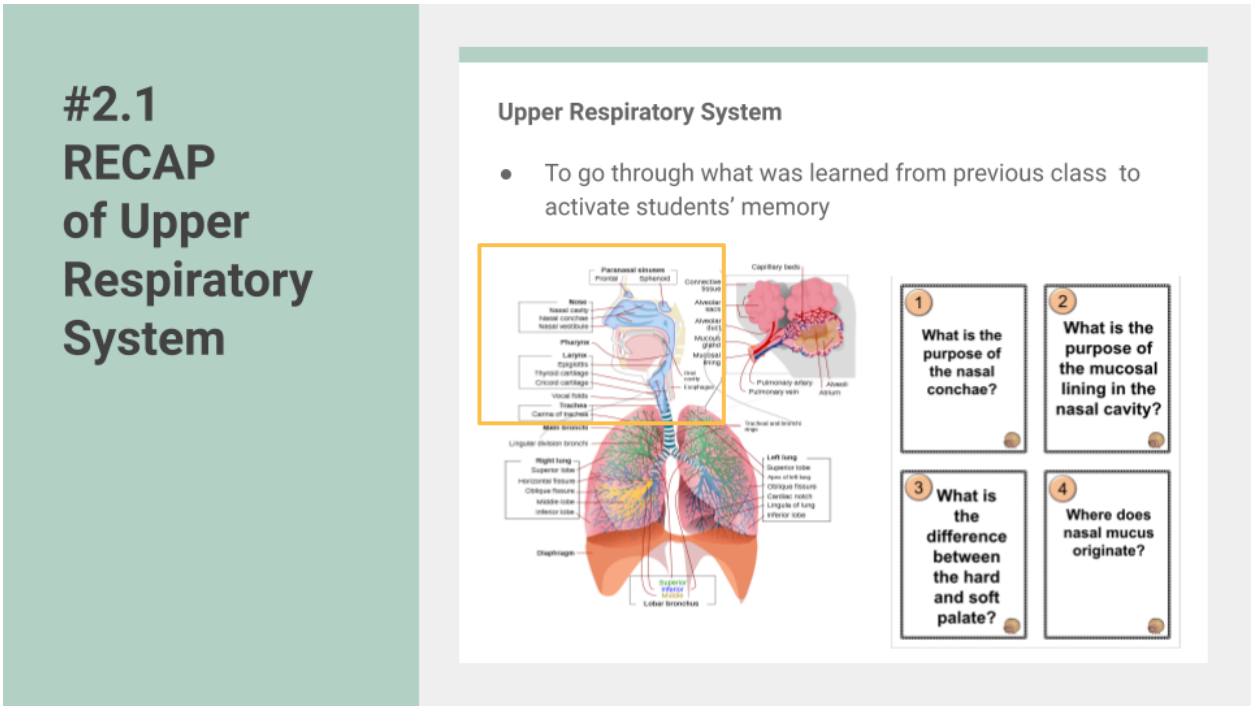
Theoretical Foundation

The icebreaker activity serves as an introduction to the lower respiratory system to promote **correlative subsumption learning** as students expand their understanding of the breathing process from the upper respiratory system to the lower respiratory system,

and correlate breathing with the lung volume. More importantly, we value students' emotions and motivations a lot, so we are hoping that the simple and engaging nature of the simulation will help students to have a more positive attitude toward learning biology, in accordance with the **affect design** principles.

Section #2

#2.1 RECAP on Upper Respiratory System



Teacher's Memo

Option 1: Teacher-led Recap

1. Teacher to lead the recap session at the beginning of class by quizzing the whole class on previous class content
    a. Material Example
        i. Quiz cards shown in the slides
2. Teacher to lead the recap session by quizzing individuals on previous class content
    a. Material Example
        i. Individual sheets that have blank spaces to be filled in

Option 2: Student-led Recap (Recommended)

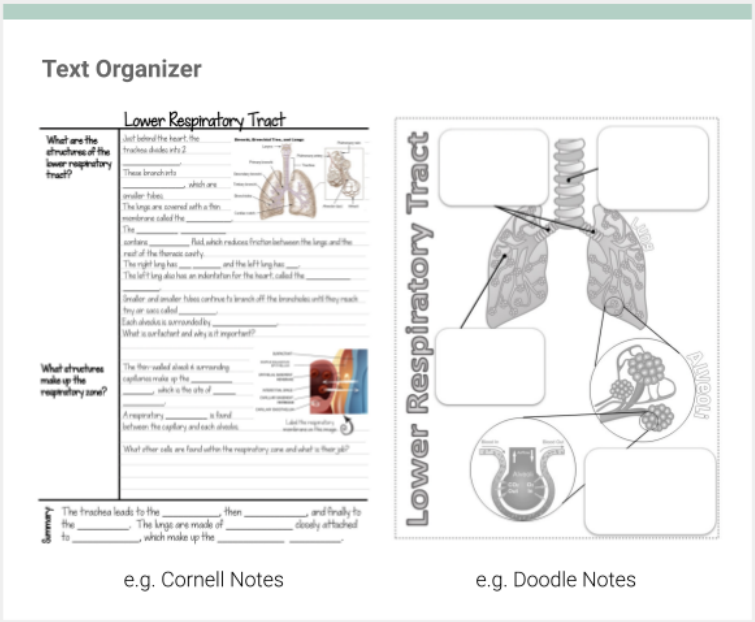
1. One student is selected at random to present the summary content from the previous class using both diagrams and words. After their presentation, which is approximately 5-10 minutes in length, other students and the instructor discuss or respond to the presentation

Theoretical Foundation

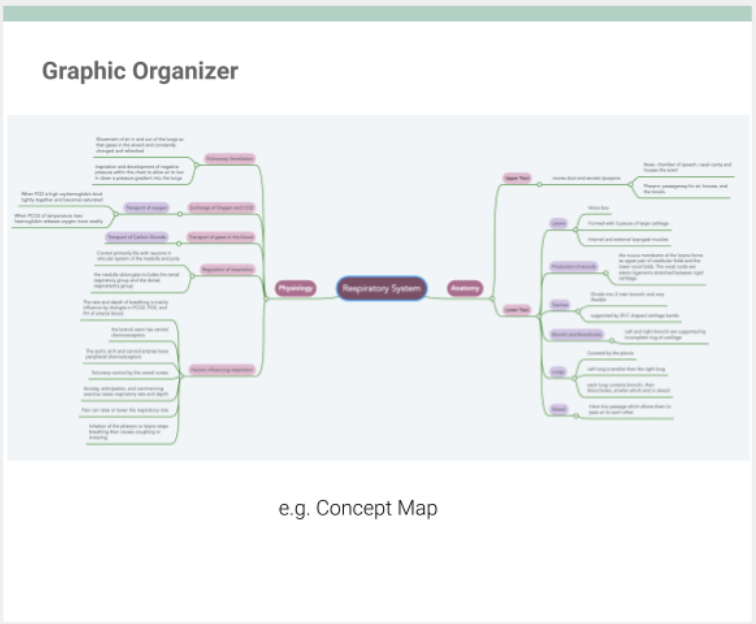
Recaps are a very common teaching strategy wherein an instructor begins a class period by briefly recapping, situating, and/or summarizing salient information discussed in a previous class period (Wyse, 2014). **Retrieval practice** is another familiar and widely used teaching technique also known as practice testing (Roediger & Butler, 2011). It describes any strategy in which a learner actively brings information to mind through deliberate recall from their long-term memory. Retrieval practice sessions often resemble quizzes, though are frequently delivered as learning activities with little or no penalty for incorrect responses. Retrieval is an active reconstruction process, not a playback of a memory of an event, fact, concept, or process. According to Huddleston, every time a memory is accessed for retrieval, that process modifies the memory itself; essentially re-encoding the memory. Multiple retrievals in multiple contexts are superior for long-term retention, for example, think frequent and low-stakes quizzes which are cumulative(Huddleston, n.d.). Retrieval makes the memory itself more recallable in the future.

#2.2 ADVANCED ORGANIZER

#2.2
ADVANCED
ORGANIZER
(opt #1)



#2.2 ADVANCED ORGANIZER (opt #2)



Teacher's Memo

Option 1: Text Organizers

1. Examples
    a. Guided Notes provided for students - example materials shown in 1st slides (Recommended)
    b. Verbal Directions

Option 2: Graphic Organizers

1. Examples
    a. Concept Maps shared with students - an example material shown in 2nd slides (Recommended)
    b. Cluster Maps

Tips:

1. Consistent - Be consistent when using text or graphic organizers in the instructional design of a lesson.
2. Coherent - Be coherent when preparing a lesson, so the organizer is clear and precise.
3. Creative - Be creative when presenting the lesson to capture the attention of the learner.

Theoretical Foundation

Advance Organizers provide an organizational framework that instructors develop prior to presenting information to students. This framework prepares students for what they are about to learn and can help provide links between new ideas and similar concepts. According to Ausubel, when students use Advance Organizers, they can bridge the gap between learning new information and information they already know (previously existing schema into new schema). "With the use of an advance organizer, new material will be rendered as more familiar and meaningful, as learners will have an

organized structure in place to store new ideas, information, and concepts." (Allen, 2014) In short, this kind of structure makes transparent for students the back-thinking and connections that instructors use to plan what new information should be taught from class to class, thus taking the guesswork out of making these connections for students and potentially deepening student understanding of the new material. Studies support a high rate of student success when organizers are presented before new material, the organizer is neatly displayed using pictures or text, and the organizer provides an example that shows a relationship between the organizer and the new material. (Corkill, 1992)

Text Organizers

Text Organizers can consist of guided notes, verbal directions, or pre-questioning techniques. Text organizers can assist students while taking notes during the presentation of lecture material. These organizers reduce the number of information students must write, but keep students engaged in the lesson by requiring some active note-taking. The notes create an outline for students that not only reduce writing demands but also makes clear the organization of ideas for a lesson. Students in any given class will process the information being presented in a lesson at differing speeds. This technique makes it more likely that all students will leave class with the necessary information and connections to master and apply the new material(Konrad, 2010).

Graphic Organizers

Graphic Organizers capitalize on both linguistic and non-linguistic styles of information storage. They include concept maps, cluster maps and etc.(Coffey, 2006). Concept maps have shown potential for facilitating knowledge retention and transfer as compared with reading text passages, listening to lectures, and participating in class discussions (Nesbit, 2006), by simply helping to bridge the gap between different types of student learners and their learning preferences.

Section #3

#3.1 INTRO to LRS & 3.2 VIDEO of LRS

#3.1 INTRO to LRS

Lower Respiratory System

- Sequence the general lower respiratory system and identify their functions

Instruction details:

- Teacher to show a video that demonstrates the LRS
- Teacher to explain LRS in depth with slides
- Students are required to fill out the Cornell Note and Doodle Note

#3.2 Biological Nouns

Instruction details:

- Teacher to hand out the prefixes and suffixes worksheets for respiratory system

Respiratory System

- **Prefixes**

ex-	out
in-	in
inter-	between
oxy-	oxygen
para-	near
re-	again

Suffixes

-centesis	drainage
-ectomy	excision, resection
-lysis	release
-plasty	alteration, reposition, repair, replacement, supplement
-rrhaphy	repair
-tomy	drainage

Teacher's Memo

1. Teacher to play an animation to introduce the essential process of gas exchange in LRS, as well as the biological nouns.
2. Teacher to hand out prefixes and suffixes worksheets for students to match words and meaning.
3. Teacher to introduce the concepts in depth with slides and ask students to take notes in Cornell notes and Doodle notes.

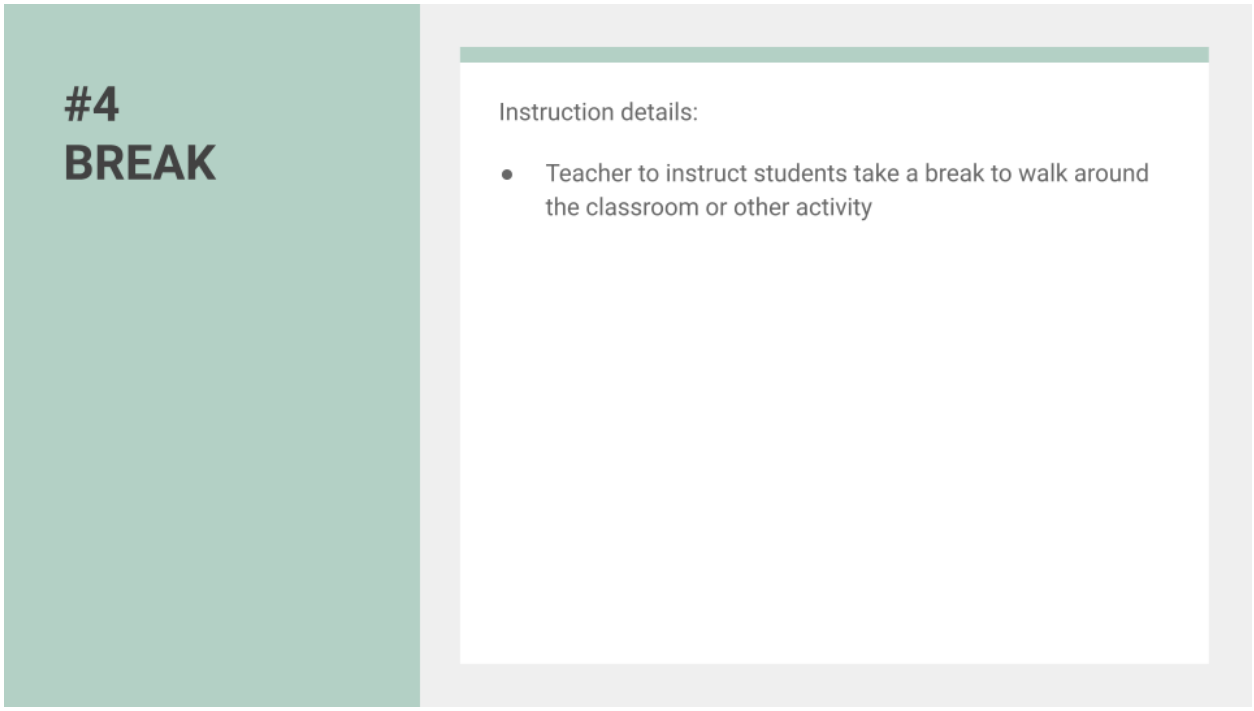
Theoretical Foundation

Since complicated medical nouns are inevitable when learning the structure of LRS, how to better communicate abstract biological knowledge and enhance memorization is our main focus. The design of this section mainly utilizes an introductory animation and prefixes&suffixes worksheets to create a more effective **representational learning** experience, primarily informed by the multimedia learning theory and cognitive load theory.

The introductory animation will talk students through the whole process of gas exchange in LRS, during which students will take notes in the provided Cornell notes and Doodle notes. Students are exposed to both visual and auditory channels, which will help them better select and organize the essential information according to the **dual-coding theory**. What's more, the animation also follows the **modality principle**, **signaling principle**, and **personalization** principle, in the sense that it provides the spoken text in a conversational style and highlights the most important concepts.

The prefixes&suffixes worksheet is an attempt to manage students' **intrinsic load** by providing non-transient material of the essential information for students to revisit afterward. According to the **transient information effect**, transient information stays in the working memory, whereas non-transient material, such as the worksheet that we provided for each student, is better retained for students to revisit, and thus, is more likely to transfer from working memory to long-term memory. Also, matching prefixes&suffixes and actual meanings adopt the **chunking strategy** to provide a pattern for them to memorize with less effort.

Section #4



Teacher's Memo

1. Teacher to initiate a 10-15 minutes break

Theoretical Foundation

Working memory conveys short-term information storage plus the role of doing work on information(Baddeley, 1986). According to Martinez, teachers need to appreciate the most design feature of working memory as it has a limited capacity. It is, therefore, necessary for instructors to not overwhelm learners' working memory. In order to preserve the contents in learners' **long-term memory**, only very limited amounts of novel information can be processed at any given time. Studies have shown that the human brain may need regular breaks when learning to help it refresh its "working memory" capacity (Chen et al., 2017). Chen and Sweller also state that working memory does recover quickly once someone takes a break from a mentally challenging task. Specifically, Chen and Sweller suggest working for 20 or 30 minutes and then taking about a five-minute break to refresh with younger learners, however, with adolescent learners, both learning and break duration could be increased accordingly. Breaks keep our brains healthy and play a key role in cognitive abilities such as reading comprehension and divergent thinking - the ability to generate and make sense of novel ideas (Immordino-Yang et al., 2012).

Section #5

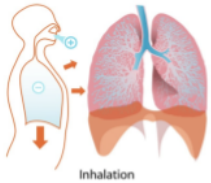
#5.1 INTRO to Breathing & #5.2 CALCULATION in Breathing

#5.1 INTRO to Breathing

How does Breathing occur?

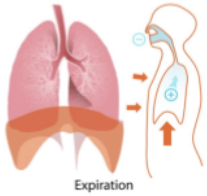
- The **diaphragm** is a large, flat muscle connected to the ribs at the bottom of the chest cavity. The **external intercostals** are muscles found between each rib of the rib cage.

- By contracting the diaphragm and intercostals, the rib cage expands, decreasing the pressure inside the lungs, causing air to rush in.
  - This is called **inspiration** or inhalation.



Inhalation

- Relaxing theses muscles causes the rib cage to decrease in size, increasing the pressure in the lungs and causing air to rush out.
  - This is called **expiration** or exhalation.

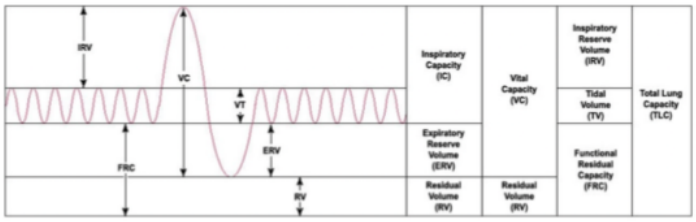


Expiration

#5.2 CALCULATION in Breathing

How is Lung Capacity Determined?

- **Tidal volume**= the amount of air that is exchanged by the lungs at rest
- **Inspiratory reserve volume**= the additional amount of air that can be inhaled consciously
- **Expiratory reserve volume**= the additional amount of air that can be exhaled consciously
- **Residual volume**= the amount of air remaining in lungs after a forced exhalation
- **Vital capacity**= amount of air someone can consciously exchange with the environment (inhaling and exhaling)
- **Total lung capacity**= vital capacity + residual volume (about 6 liters for adult men, 10% less for adult females)



Teacher's Memo

1. Teacher to instruct with PowerPoint
2. Teacher to contain material using both words and pictures/graphics near each other
3. Teacher to highlight keywords/key terms when presenting text-based content

The above slides are shown as examples for teachers to refer to.

Theoretical Foundation

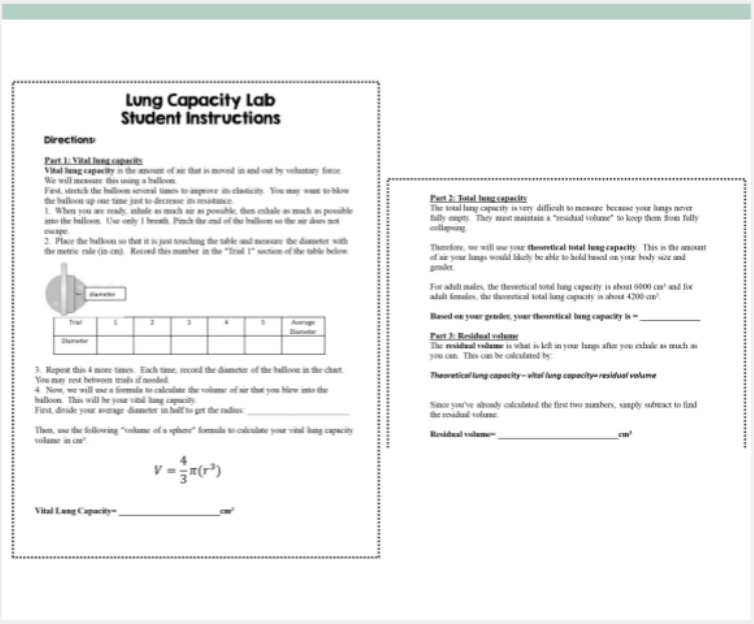
A cognitive explanation to the use and effectiveness of PowerPoint is provided by Mayer's **multimedia theory of learning** (Mayer, 2001), in which the presentation of material using both words and pictures posits that learners can better understand an explanation when it is presented in words and pictures than when it is presented in words alone. The modes of presentation of words and pictures are simply the delivery vehicles and play a role in knowledge acquisition or knowledge construction. Mayer defines multimedia instructional messages as presentations involving both words and pictures that are intended to foster learning. Words refer to speech and printed text and pictures refer to static and dynamic graphics.

Presenting material in both visuals and verbal increases the capacity for their students to process information as the material is likened to being presented twice but through different channels. **The Dual coding theory** explains how human understanding occurs in PowerPoint presentations when learners are able to integrate or build meaningful connections between visual and verbal representations of information. Dual coding is reflected in the six principles of multimedia learning developed by Clark and Mayer (2003) which state that students learn better:

- from words and pictures than from words alone (multimedia principle)
- when corresponding words and pictures are presented near rather than far from each other on the page or screen (spatial contiguity principle)
- when corresponding words and pictures are presented simultaneously rather than successively (temporal contiguity principle)
- extraneous material is excluded when corresponding words and pictures are presented (coherence principle)

Additionally, according to Mayer and Moreno, highlighting keywords/key terms help **reduce extraneous cognitive load**, which enables the students to have a greater capacity to build and construct meaning.

#5.3 ACTIVITY Lung Capacity Lab



Lung Capacity Lab
Student Instructions

Directions:

Part 1: Vital lung capacity:
Vital lung capacity is the amount of air that is moved in and out by voluntary force. We will measure this using a balloon.
First, stretch the balloon several times to improve its elasticity. You may want to blow the balloon up one time just to decrease its resistance.
1. When you are ready, inhale as much air as possible, then exhale as much as possible into the balloon. Use only 1 breath. Pinch the end of the balloon so the air does not escape.
2. Place the balloon so that it is just touching the table and measure the diameter with the metric rule (in cm). Record this number in the "Trial 1" section of the table below.

diameter

Trial	1	2	3	4	5	Average Diameter
Diameter						

3. Repeat this 4 more times. Each time, record the diameter of the balloon in the chart. You may rest between trials if needed.
4. Now, we will use a formula to calculate the volume of air that you blew into the balloon. This will be your vital lung capacity.
First, divide your average diameter in half to get the radius: _____

Then, use the following "volume of a sphere" formula to calculate your vital lung capacity volume in cm^3.

$$V = \frac{4}{3}\pi(r^3)$$

Vital Lung Capacity= _____ cm^3

Part 2: Total lung capacity
The total lung capacity is very difficult to measure because your lungs never fully empty. They must maintain a "residual volume" to keep them from fully collapsing.

Therefore, we will use your **theoretical total lung capacity**. This is the amount of air your lungs would likely be able to hold based on your body size and gender.

For adult males, the theoretical total lung capacity is about 6000 cm^3 and for adult females, the theoretical total lung capacity is about 4200 cm^3.

Based on your gender, your theoretical lung capacity is = _____

Part 3: Residual volume
The **residual volume** is what is left in your lungs after you exhale as much as you can. This can be calculated by:

Theoretical lung capacity – vital lung capacity= residual volume

Since you've already calculated the first two numbers, simply subtract to find the residual volume.

Residual volume= _____ cm^3

#5.4 CONTRAST of Lung Capacity Lab Results

Open-ended Discussion

1. In healthy individuals, the residual volume is about 20% of the total lung capacity. How does yours compare to this?

2. How would the vital capacity of an athlete compare to a non-athlete? Why?

3 Why would lung capacity also be important to singers?

Teacher's Memo

Pre-Lab Activity

1. Teacher to introduce the final goal of this lab activity
2. Teacher to hand out aiding materials (worksheet, calculators, rulers, etc)

During Lab Activity

1. Teacher to provide scaffolds to students but without giving the answer
2. Teacher to encourage students to relate this activity to their prior knowledge or other subjects

Post Lab Activity

1. Teacher to facilitate discussions among students

Theoretical Foundation

As **Bloom's taxonom**y is a hierarchy of progressive processes ranging from the simple to the complex, this part of the lesson focuses on **Applying & Analyzing** of the hierarchy. Lab activities allow students to apply their knowledge obtained from this lesson to different situations as it involved students answering questions and solving problems. Contrasting Lab results and Class discussions enable students to draw connections between ideas, think critically, and break down information into the sum of its parts.

Additionally, while students learn through problem-solving situations, discovery learning happens. **Discovery learning** is an active, hands-on style of learning, introduced by Jerome Bruner. It employs a model of instruction and strategies that encourage students to engage actively in the learning process (Dewey, 1997; Piaget, 1973). According to Dorier and Glacier(2013), there are multiple essential components that are required for successful discovery-based learning which include the following:

- Teacher guidance where the emphasis is on building upon students' reasoning and connecting to their experiences
- Classroom culture where there is a shared sense of purpose between teacher and students, where open-mindedness and dialogue are encouraged
- Students are encouraged to ask questions, inquire through exploration and collaborate with teachers and peers

Section #6

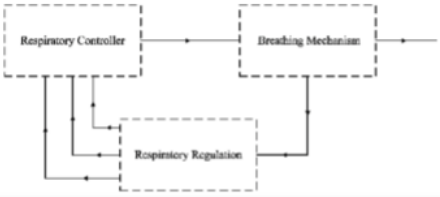
#6 Induction Activity of Breathing Regulation

Breathing

- Investigate the factors that could alternate respiration rate

Instruction details:

- Teacher to facilitate think/pair/share discussion session between students
- Teacher to have students share with class their thoughts
- Teacher to help consolidate all answers



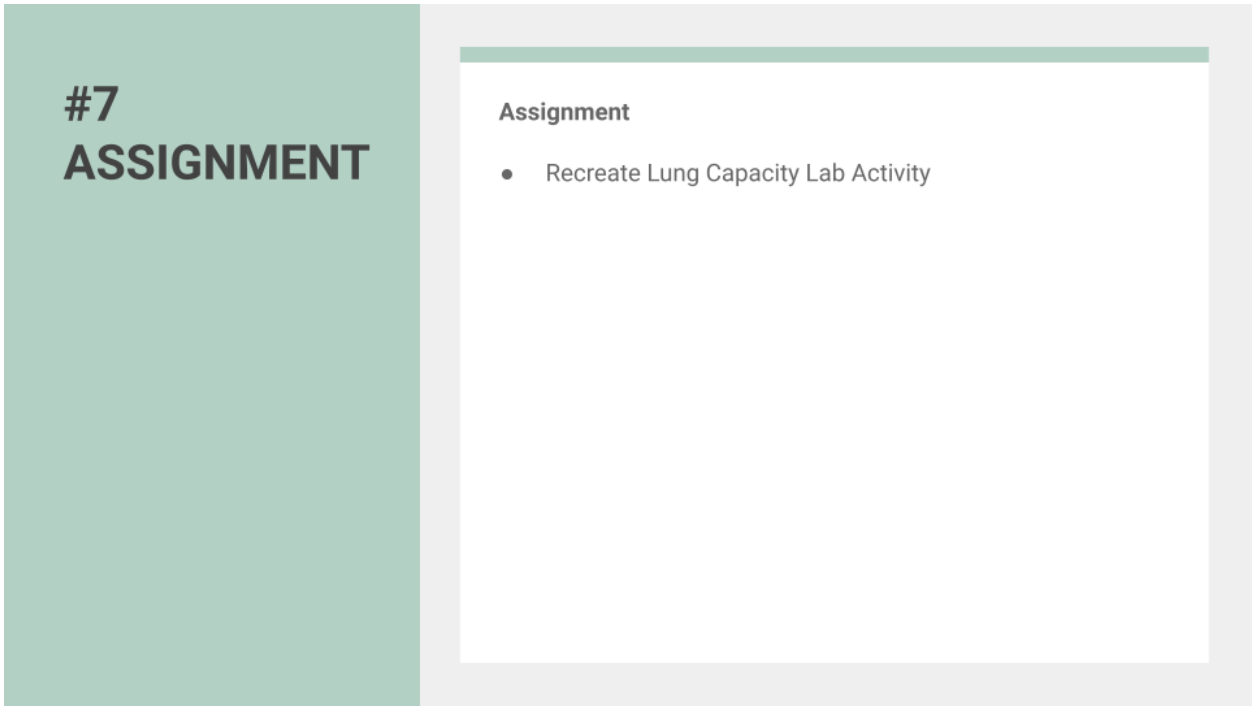
Teacher's Memo

1. Teacher to facilitate discussion for students to share when their frequency of breathing changes in daily life and investigate the factors that could alternate respiration rate.
2. Teacher to add students' answers to two main categories: Self-Controllable and Uncontrollable.
3. Teacher to help consolidate all answers.

Theoretical Foundation

For the breathing regulation mechanism, we want the students to go beyond just understanding, that is, to make connections with their real-life experiences and come to conclusions by themselves through induction to foster their **inferential reasoning** abilities. Research suggests that improvement inferential reasoning may depend upon more awareness of the multiple views taken within the community, developing teacher and student talk, and giving more opportunities to students to experience sampling behavior (Maxine, 2006). Through the process of making observation → finding pattern → building hypothesis → forming organized theory, students will not only contribute multiple views to support inferential reasoning, but also activate **deep processing** for the breathing regulation mechanism since the knowledge is encoded based on the actual meaning associated with the world (Fujii et.al., 2002).

Section #7



Teacher's Memo

1. Teacher to assign the homework: Redesign the Lung Capacity Lab Activity (5.3).

Theoretical Foundation

By recreating the lab activity, students are given the opportunity to revisit the knowledge they learned in class about lung capacity, as well as evaluate their learning outcomes. Additionally, students' **critical thinking** abilities will get practiced while they judge and criticize the activity.

Although this assignment might be a bit hard and complex, it progressively incorporates the knowledge gained from several modules in class so that the students can connect the concepts in relationships, and then **transfer** knowledge to new situations. Also, it is proved by researchers that most individuals of normal intelligence engage in **metacognitive** regulation when confronted with an effortful cognitive task. (Livingston JA., 2003) Students will have active control over the essential processes to calculate lung capacity, and thus, better understand where their weakness lies. Overall, the final stage of "**evaluating**" and "**creating**" from Bloom's Taxonomy is achieved in the assignment design as closure for the entire lower respiratory system class.

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