

Sec 3 G3 Science (Biology) Chapter 7 Notes
JURONG WEST SECONDARY SCHOOL
SECONDARY THREE – SCIENCE BIOLOGY
Chapter 7: RESPIRATION IN HUMAN

Learning Outcomes:

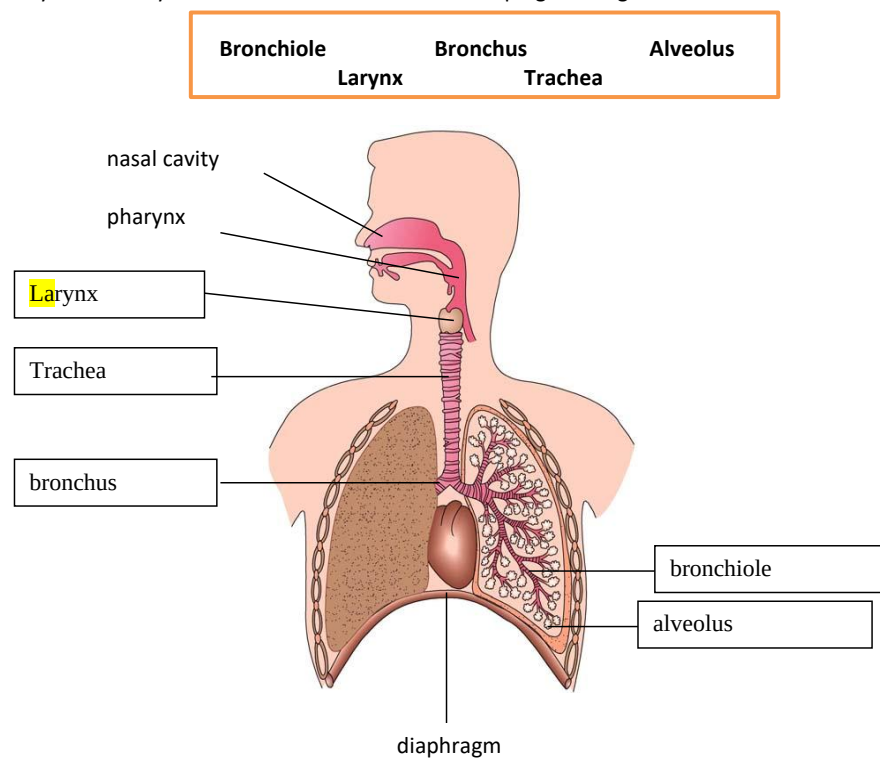
Candidates should be able to:

- (a) **identify** the larynx, trachea, bronchi, bronchioles, alveoli and associated capillaries and state their functions in human gaseous exchange
- (b) explain how the structure of an **alveolus** is suited for its **function** of gaseous exchange
- (c) state the **major toxic components** of tobacco smoke – **nicotine, tar and carbon monoxide**, and describe their **effects** on health
- (d) define **aerobic respiration** in human cells as the release of energy by the breakdown of glucose in the presence of oxygen and **state the word equation**
- (e) define **anaerobic respiration** in human cells as the release of energy by the breakdown of glucose in the absence of oxygen and state the **word equation**
- (f) explain why cells respire anaerobically during vigorous exercise resulting in an oxygen debt that is removed by rapid, deep breathing after exercise

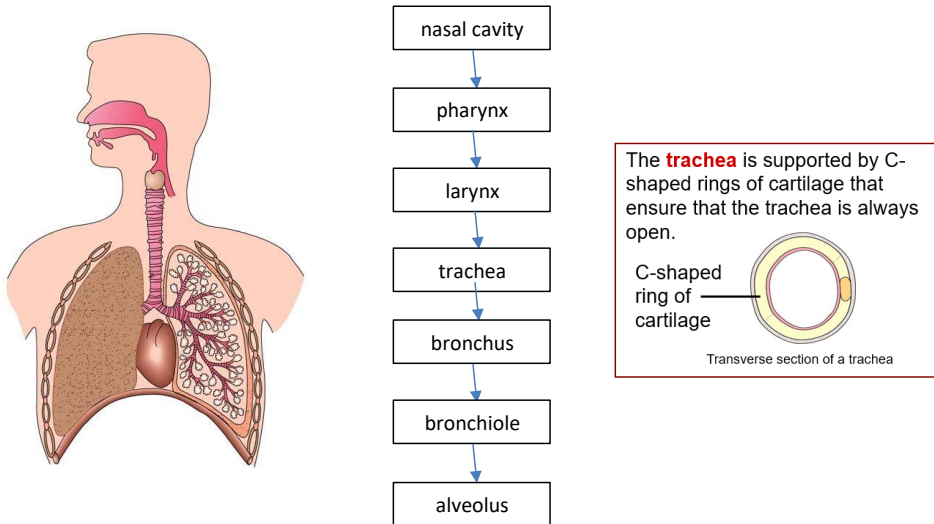
(a) identify the larynx, trachea, bronchi, bronchioles, alveoli and associated capillaries and state their functions in human gaseous exchange

VIDEO:

Play video and you will fill in the labels with the helping words given.



The Respiratory Pathway

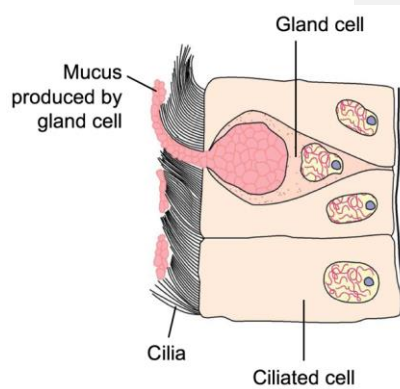


THE NOSE

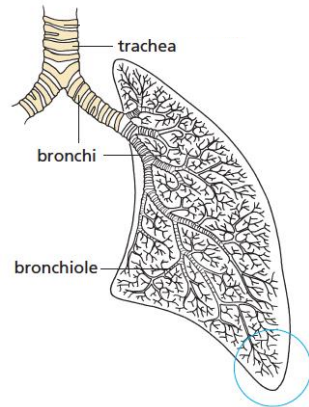
- Dust and foreign particles (e.g. **bacteria** in the air) are **trapped by the hairs** in the nostrils as well as the **mucus** on the mucus membrane.
- As air passes through the nasal passages, it is warmed and moistened.
- Harmful chemicals may be detected by the sensory cells in the mucous membrane.

TRACHEA AND BRONCHI

- Epithelium lining the trachea and bronchi consists of two types of cells
- **Ciliated cells**
 - Have **hair-like** structures called **cilia** on their surfaces.
 - Cilia **traps dust and dirt** particles, and micro-organisms and **sweep it up** towards the back of the throat and out of the nostrils
- Gland cells
 - **secrete mucus to trap dust and microorganisms (virus and bacteria) in the air.**

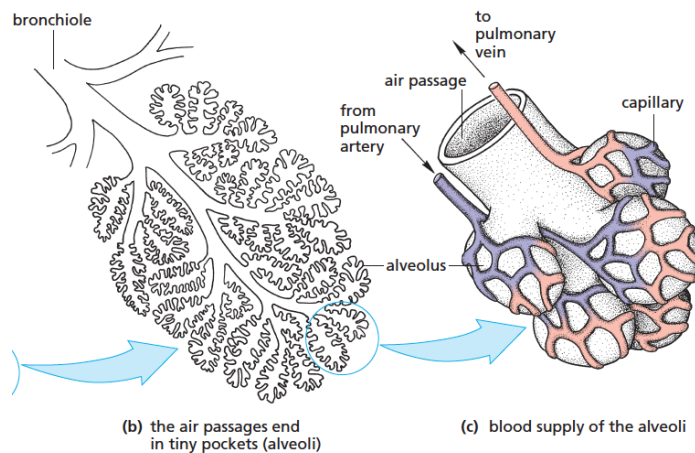


- Trachea divides into two **bronchi** (plural) that branch repeatedly to give rise to bronchioles.



- ☐ (b) explain how the structure of an alveolus is suited for its function of gaseous exchange

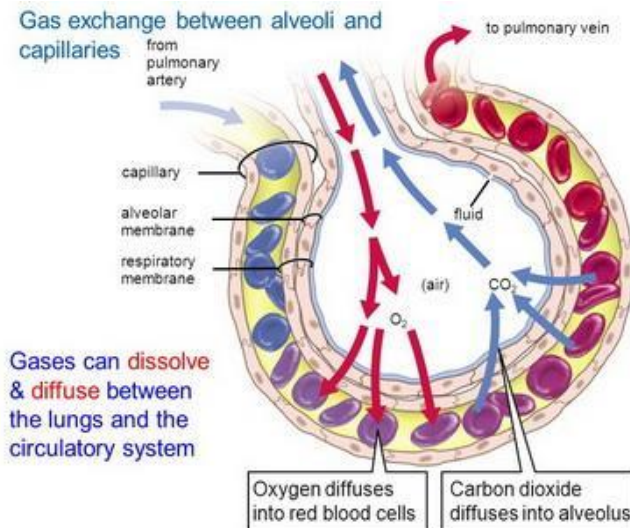
ALVEOLI / ALVEOLUS



- Trachea divides into two **bronchi**. Each bronchus branches out repeatedly into numerous **bronchioles**, which end with a cluster of **alveoli**.
- Site of gaseous exchange → **Gaseous exchange** occurs by **diffusion**, oxygen diffuses from alveolus and into the RBC, carbon dioxide diffuses from plasma and into the alveolus.

3. Thousands of alveoli are found in the lungs to provide a **very large surface area** for gaseous exchange.

Adaptations and Functions of an alveolus



(Image from <https://d2gne97vdumgn3.cloudfront.net/api/file/vRDE0vKRruk2LWPdfQX>)

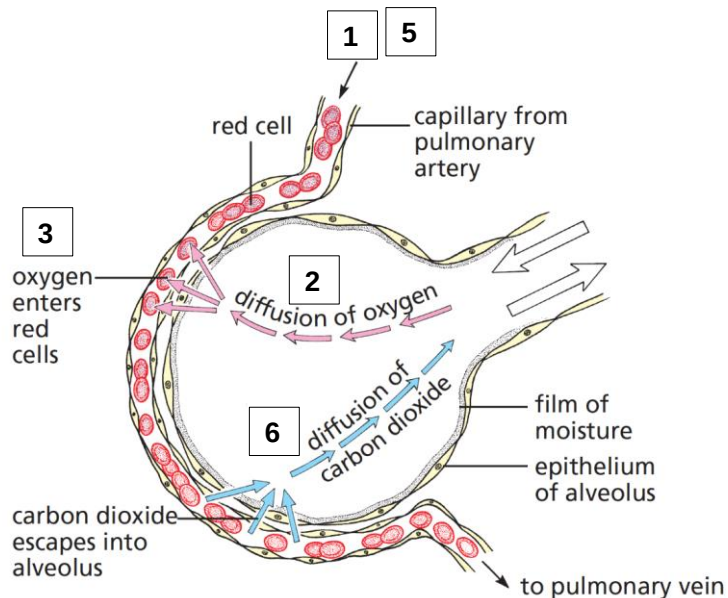


Structure	Function
One-cell thick alveolar wall	Shorter distance for diffusion of gases, faster diffusion of gases
Thin film of moisture in the alveolus	Allows oxygen to dissolve and diffuse across the alveolar walls easily
Many blood capillaries surrounding the alveoli	A constant blood flow maintains the steep concentration gradient of gases, ensuring faster diffusion.
<i>Numerous alveoli in the lungs (**do not use this point if question is asking for the adaptation of <u>an alveolus</u>)</i>	<i>Provide a large surface area for gaseous exchange</i>

QUESTION: WE BREATHE IN OXYGEN. True or False?

False. We breathe in AIR, which contains 20.95% oxygen

Gaseous exchange (diffusion)



1. Blood entering lungs (and hence capillaries which surround the alveoli) have:
 - **low** concentration of oxygen and
 - **high** concentration of carbon dioxide.
2. Oxygen **dissolves** into the thin film of moisture and then **diffuses** into the capillaries.
3. Oxygen combines with **haemoglobin** in the RBCs, forming **oxyhaemoglobin**.
4. When blood passes through oxygen-poor tissues, **oxyhaemoglobin** releases oxygen which **diffuses** through capillary walls to reach tissue cells.
5. Blood entering lungs (and hence capillaries which surround the alveoli) have:
 - **high** concentration of carbon dioxide.
6. Carbon dioxide **diffuses** from the blood capillary into the alveolus.

QUESTION: Carbon dioxide is transported in the blood. Via blood plasma or RBC?

Gaseous exchange

Cells $\rightleftharpoons$ tissue fluid $\rightleftharpoons$ blood in blood capillaries

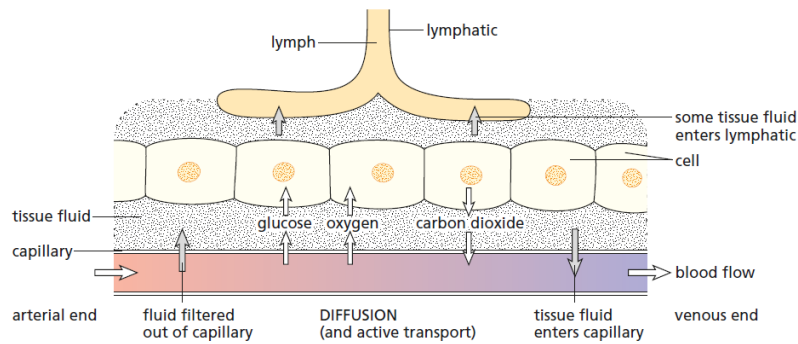


Figure 9.19 Blood, tissue fluid and lymph

Inspired VS Expired air

Do you think inspired air (air you inhale) is the same as expired air (air you exhale)?

Component	Inspired air	Expired air
Oxygen	~ 21%	~ 16.4%
Carbon dioxide	~ 0.03%	~ 4%
Nitrogen	~ 78%	~ 78%
Water vapour	Variable (rarely saturated)	Saturated

INVESTIGATION

What about temperature?

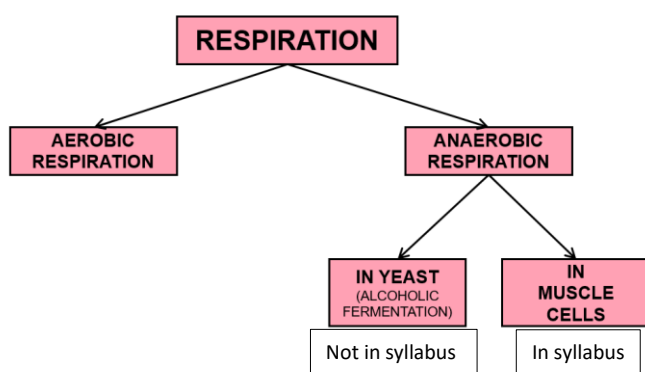
*Place your hand near your nostrils and feel the air you exhale.
Is it warmer or cooler than inspired air?*



(d) define aerobic respiration in human cells as the release of energy by the breakdown of glucose in the presence of oxygen and state the word equation

(e) define anaerobic respiration in human cells as the release of energy by the breakdown of glucose in the absence of oxygen and state the word equation

(f) explain why cells respire anaerobically during vigorous exercise resulting in an oxygen debt that is removed by rapid, deep breathing after exercise



RESPIRATION IS NOT BREATHING

- Tissue Respiration (chemical process)
 - oxidation of organic food substances(glucose) with the release of energy,
- Gaseous Exchange (physical process)
 - process of the **transfer of oxygen** from the surrounding to the cells and **carbon dioxide** from cells back to surrounding.

What is respiration?

- Respiration supplies energy for muscle contraction, germination and cell division.
- There are two types of respiration: **Aerobic Respiration (with oxygen)**
Anaerobic Respiration (without oxygen)

1. Aerobic respiration

- Aerobic respiration is the breakdown of **glucose** in the presence of **oxygen** with the **release of large amount of energy**.
- **Carbon dioxide and water** are released as by-products.
- It takes place in the **mitochondria** (organelle in cells).
- Occurs in all body cells.



- Write the word equation for aerobic respiration:



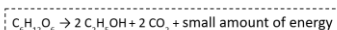
Glucose + oxygen → carbon dioxide + water + large amount of energy

- Anaerobic respiration is the breakdown of ~~food substances~~ **glucose** with the release of a comparatively **small amount of energy** in the **absence of oxygen**.
- **Lactic acid** is released as by-products. (Lactic acid causes muscle soreness.)
- It takes place in the **cytoplasm**.
- Occurs in the **muscle cells** in humans. *It also happens in other cells.*
- Write the word equation for anaerobic respiration:

Glucose → lactic acid + small amount of energy

***NOTE! There is no carbon dioxide produced! No water produced!**

ANAEROBIC RESPIRATION (yeast) (FYI)
chemical equation



word equation

glucose → ethanol + carbon dioxide + small amount of energy



TRY YOURSELF!

List five distinguishing features between aerobic and anaerobic respiration.

 Aerobic respiration	 Anaerobic respiration
• Oxygen is required • Large amount of energy is released • Carbon dioxide and water are produced • Takes place in the <u>mitochondrion</u>	• Oxygen not required • Small amount of energy is released • Lactic acid is produced in humans • Takes place in the <u>cytoplasm of muscle cells</u>

What happens during exercise?



- Muscles **contract vigorously** to enable movement, hence **requires more energy**.
- **Aerobic respiration** occurs at a high rate.
- Increase in **breathing rate** to **take in oxygen** and **remove carbon dioxide** rapidly.
- Increase in **heart rate** to increase the **transport** of oxygen and glucose to the **muscle cells** for **increased** rate of **aerobic** respiration.



What happens if the breathing rate and heart rate cannot increase any further?

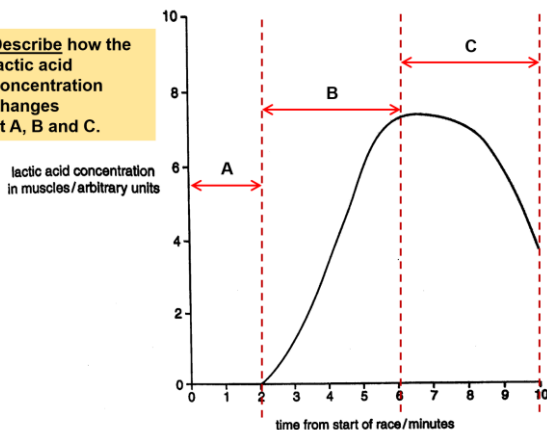
- **Anaerobic respiration** takes place in muscle cells **(in addition to aerobic respiration)** to release small amount of energy. This allows muscular contractions to continue.
- **Lactic acid** is produced during this process. **The body is said to have suffered an oxygen debt. (oxygen debt is paid when we stop exercising + breathing rate is still high)**
- Accumulation of lactic acid results in soreness in muscles (muscles fatigue).
- Lactic acid will be broken down/oxidised in the liver.
 - **lactic acid is oxidized to release energy.** **(this happens when we stop exercising + breathing rate is still high)**
 - This energy is **used to convert the remaining lactic acid to glucose**.
 - Glucose is then **transported back to the muscle**.

See-think-wonder

Let's Think!

An athlete runs a race in six minutes.
The figure shows the lactic acid concentration in his muscles **during** and **after** the run.

Describe how the lactic acid concentration changes at A, B and C.



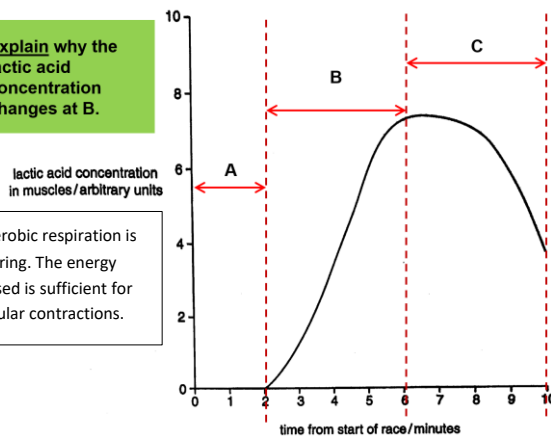
Describe:

From 0-2 minutes from start of the race, lactic acid concentration is zero arbitrary units.

From 2-6 minutes from start of the race, lactic acid concentration **increases** from 0 to 7 arbitrary units.

From 6-10 minutes from start of the race, lactic acid concentration **decreases** from 7 to 4 arbitrary units.

Explain why the lactic acid concentration changes at B.



Explain why the lactic acid concentration changes at C.

Note:
At C, the athlete still has a high breathing rate to take in oxygen, even though exercise has stopped.

C

Exercise has stopped. Lactic acid is gradually removed from muscles and transported to the liver.

In the liver, lactic acid is oxidized to release energy. This energy is used to convert remaining lactic acid into glucose. Oxygen debt is repaid.

A: Aerobic respiration is occurring. The energy released is sufficient for muscular contractions.

B

When breathing rate and heart rate cannot increase any further, anaerobic respiration takes place, to release a **small amount of energy** in addition to the energy released by aerobic respiration.

This produces lactic acid too.

EXTENSION:

"It is much more **painful** to complete a 200m-sprint than to run 1km jog."
Do you agree? Discuss.



(https://www.bodybuilding.com/fun/images/2010/sprint-vs-marathon-energy-demands_l.jpg)

During a sprint, there is more vigorous muscular contractions **per unit time** in order for the athlete to run faster.

aerobic respiration occurs at a high rate.

Increase in breathing rate to take in oxygen and **remove** carbon dioxide rapidly.

However, breathing rate and heart rate cannot increase further to release energy fast enough so anaerobic respiration takes place in addition to aerobic respiration. Lactic acid is built up and causes muscle fatigue.

- ☐ (c) state the major toxic components of tobacco smoke – **nicotine, tar and carbon monoxide**, and describe their effects on health

SMOKING & EFFECTS OF TOBACCO SMOKE

Three major toxic components of tobacco smoke:

1. Nicotine

- **Addictive** substance
- Stimulates the production of **adrenaline (hormone)**
→ Causes the **increase of heartbeat rate and blood pressure**
- Makes **blood clot easily**
→ Increases risk of blood clots in the arteries
→ Increases risk of **coronary heart disease**

2. Tar

- Causes **uncontrolled cell division**
→ Increases the risk of **cancer** in the lungs
- **Paralyses cilia** lining the air passages
→ **Dust particles trapped in mucus lining** the air passages cannot be removed, thus increasing the risk of **chronic bronchitis and emphysema** (destruction of the wall of alveoli)

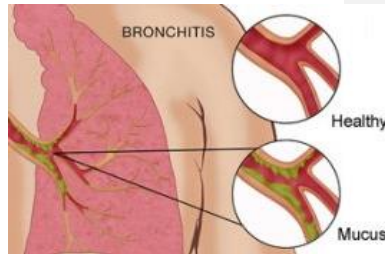
3. Carbon monoxide

- Combines with **haemoglobin** to form **carboxyhaemoglobin**
→ **Reduces efficiency of oxygen transport** by red blood cells
- Increases the rate of **fatty deposits on the inner arterial wall**
→ Increases risk of **coronary heart disease**

Diseases caused by Tobacco Smoke

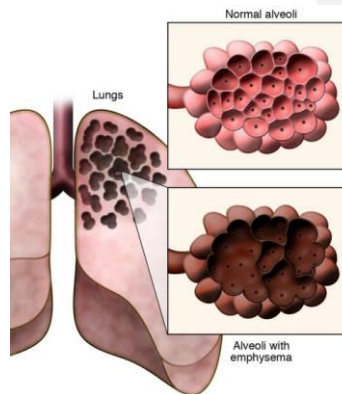
Chronic (long term) bronchitis

- Air passages are blocked due to:
 - Inflamed epithelium lining of air passages
 - Excessive mucus secreted by epithelium
 - Cilia on epithelium are paralysed
→ cannot remove mucus and dust particles
- Results in breathing difficulties, persistent coughing to clear air passages, high risk of lung infections.



Emphysema

- Partition walls between alveoli break down
→ decreased surface area for gas exchange
- Lungs lose elasticity and becomes inflated with air
→ less difference between atmospheric and lung pressure.
- Results in shortness of breath (difficulty in breathing) due to lack of oxygen uptake in lungs



Heart disease

- Smokers have a higher risk of developing heart diseases
- Major factors:
 - Nicotine: causes heart to beat faster and raises blood pressure
 - Carbon monoxide: decreases oxygen content in blood
- May lead to heart attack

Lung cancer

Major factors:

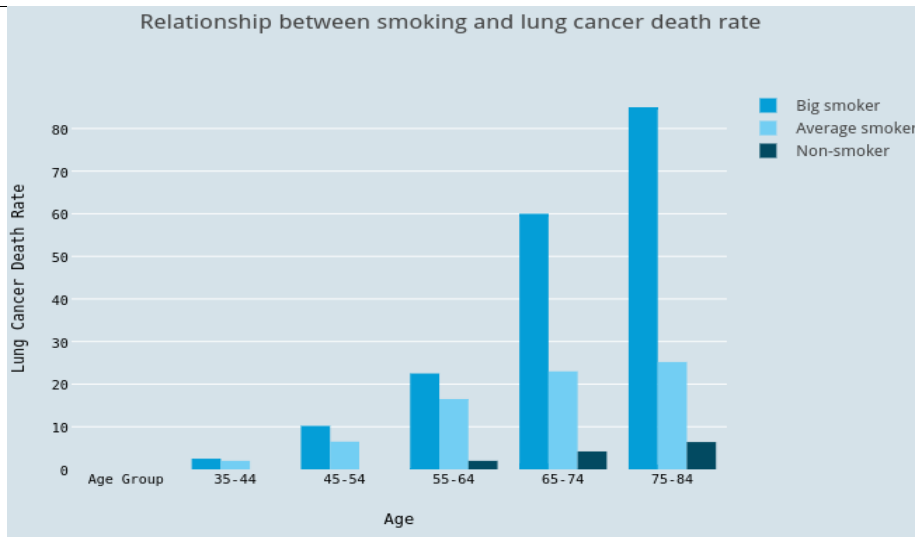
- Tar causes uncontrolled cell division
- Benzopyrene is a deadly carcinogen in tobacco smoke



CLASS DISCUSSION:

[Claim-Support-Questioning]

Let's Think!



Claim: SMOKING CAUSES LUNG CANCER

Support: *(Provide evidence to support the claim. Jot down your points to justify the claim)*

Commented [1]: From the graph, generally the big smokers die from lung cancer. (QUOTE)
Tobacco smoke contains tar which is carcinogenic and increases the risk of uncontrolled cell division

Question: *(Ask questions about the claim. What's left hanging? What else isn't explained? What new reasons does your claim raise? Jot down questions which you may wonder)*

Commented [2]: How did the non-smokers develop lung cancer?
Is tar the only carcinogenic substance to cause lung cancer?
What other ways are there to develop lung cancer?



The End