# Buffer & Blood pH

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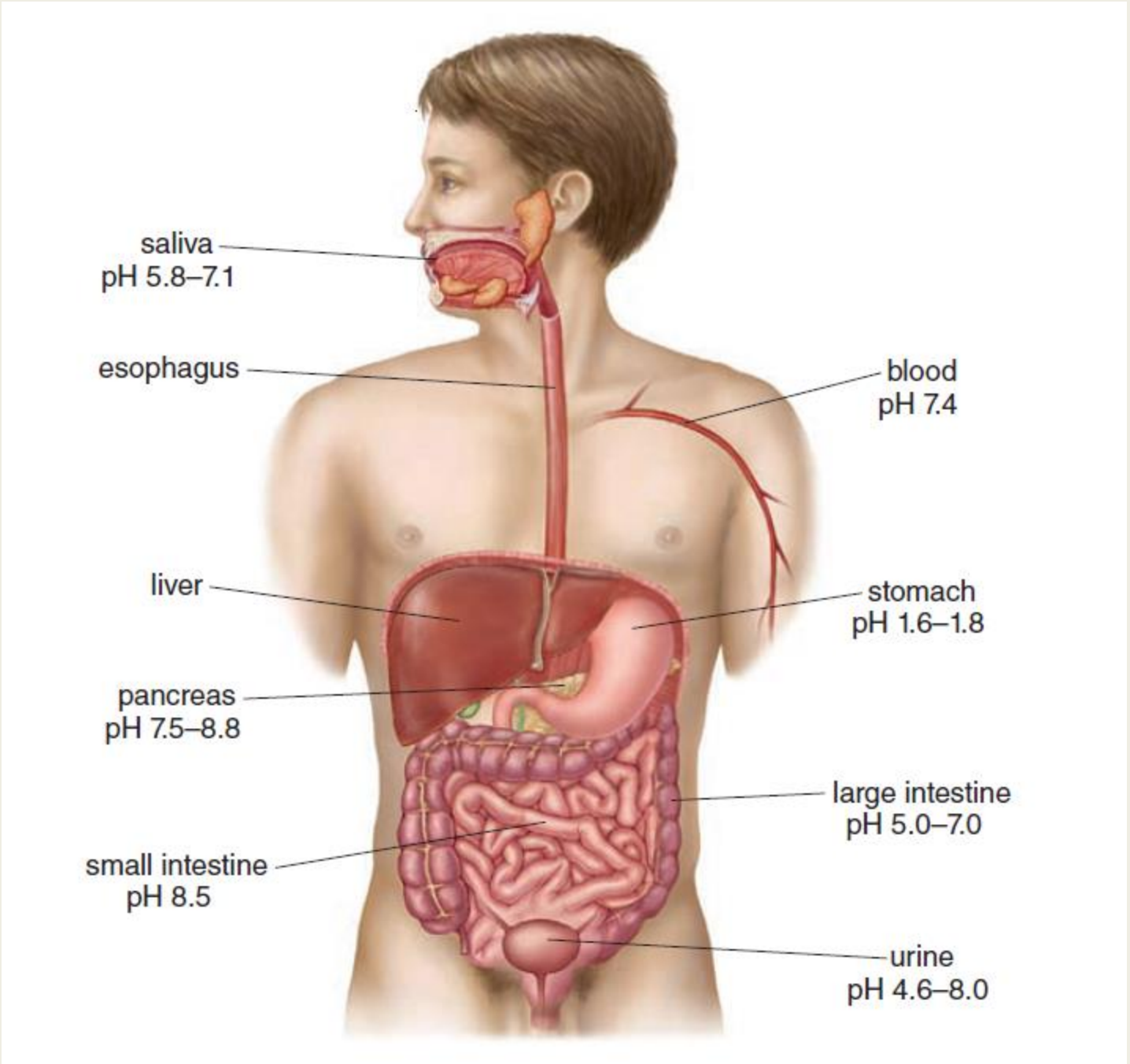
*Lecture 7*

# 6. The pH of Body Fluids

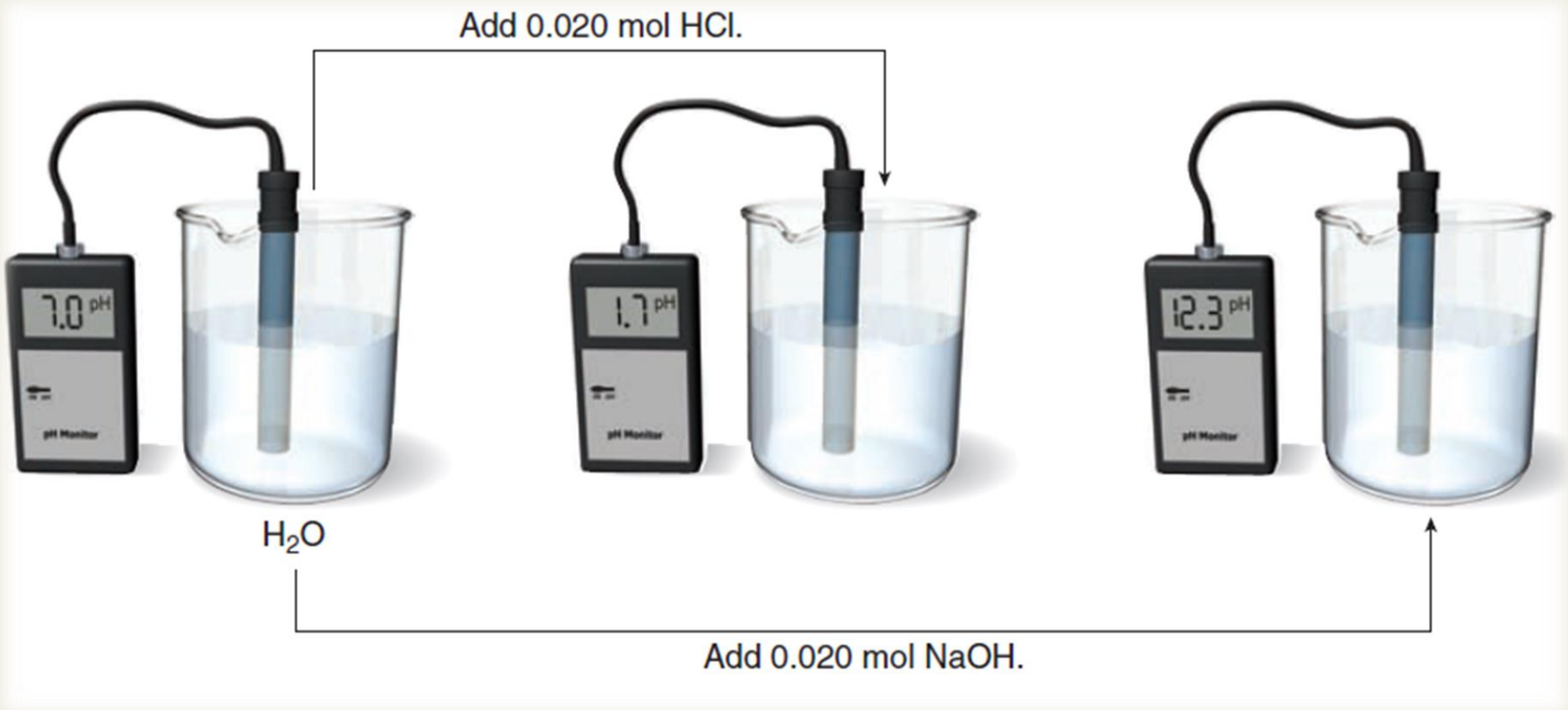
- The human body contains fluids that vary in pH as shown in Figure 8.8.
- While saliva is slightly acidic.
- The gastric juice in the stomach has the lowest pH found in the body. The strongly acidic environment of the stomach aids in the digestion of food. It also kills many types of bacteria that might be inadvertently consumed along with food and drink.
- When food leaves the stomach, it passes to the basic environment of the small intestines. Bases in the small intestines react with acid from the stomach.
- The pH of some body fluids must occupy a very narrow range. For example, a healthy individual has a blood pH in the range of 7.35–7.45. Maintaining this pH is accomplished by a complex mechanism described in Section 8. The pH of other fluids can be more variable. Urine has a pH anywhere from 4.6–8.0, depending on an individual's recent diet and exercise.


saliva
pH 5.8–7.1
esophagus
blood
pH 7.4
liver
stomach
pH 1.6–1.8
pancreas
pH 7.5–8.8
large intestine
pH 5.0–7.0
small intestine
pH 8.5
urine
pH 4.6–8.0

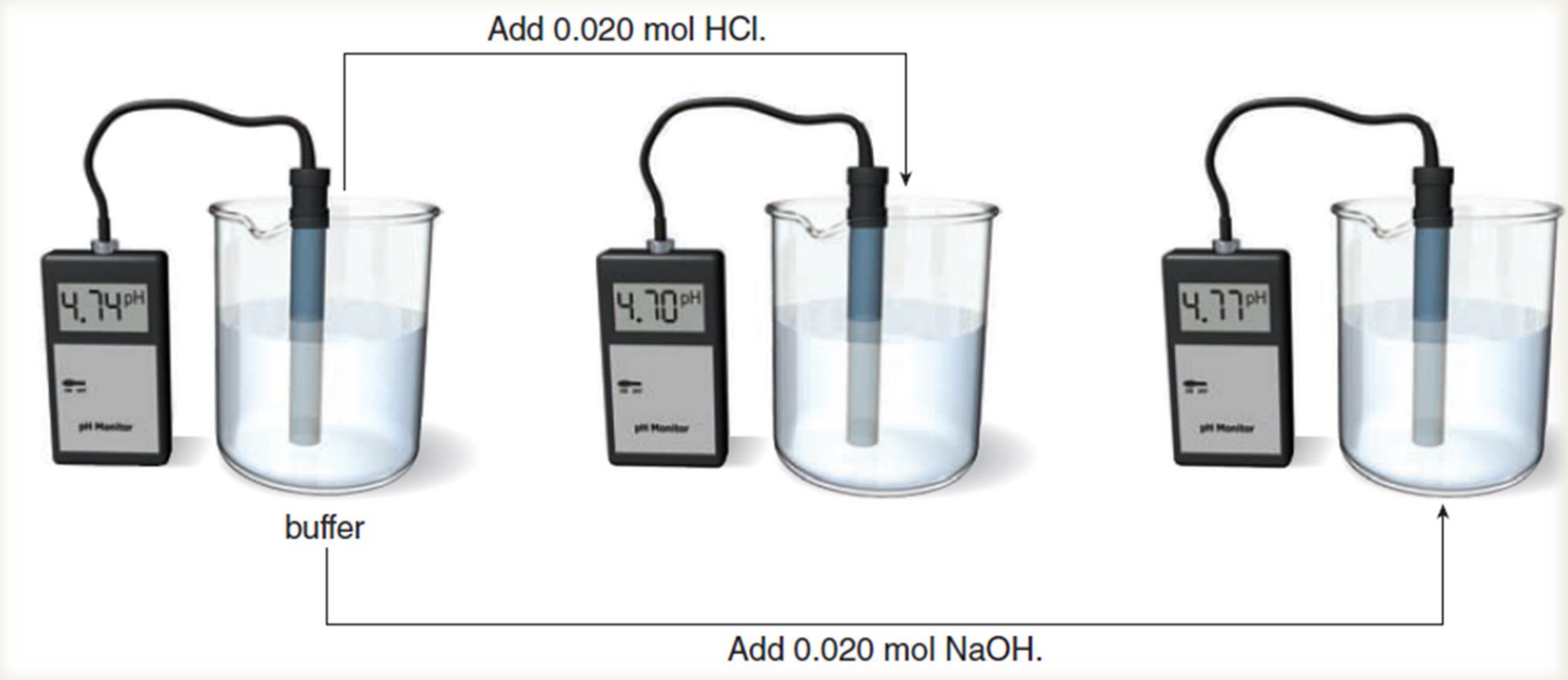
# 7.Buffers

- A buffer is a solution whose pH changes very little when acid or base is added. Most buffers are solutions composed of approximately equal amounts of a weak acid and the salt of its conjugate base.

- The weak acid of the buffer reacts with added base, $^{-}OH$.
- The conjugate base of the buffer reacts with added acid, $H_3O^{+}$.



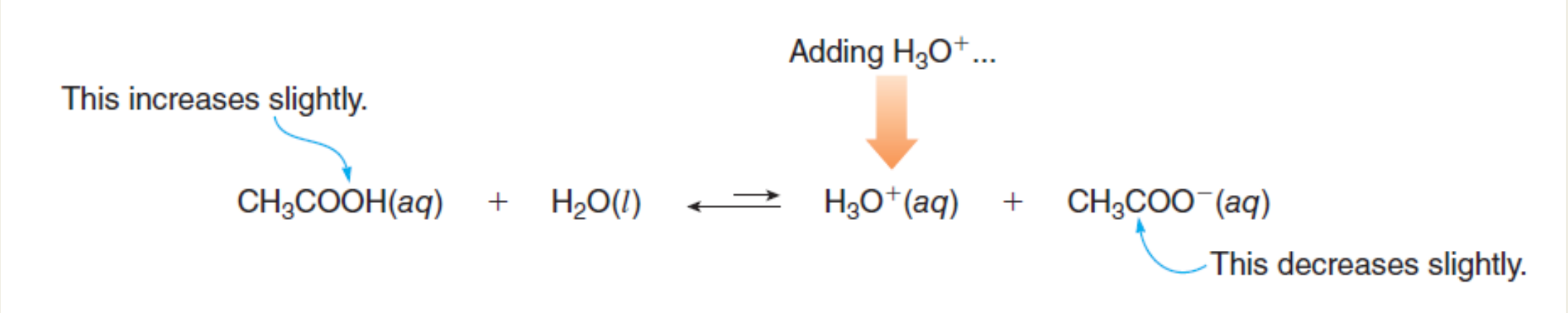

- The effect of a buffer can be illustrated by comparing the pH change that occurs when a small amount of strong acid or strong base is added to water, with the pH change that occurs when the same amount of strong acid or strong base is added to a buffer.



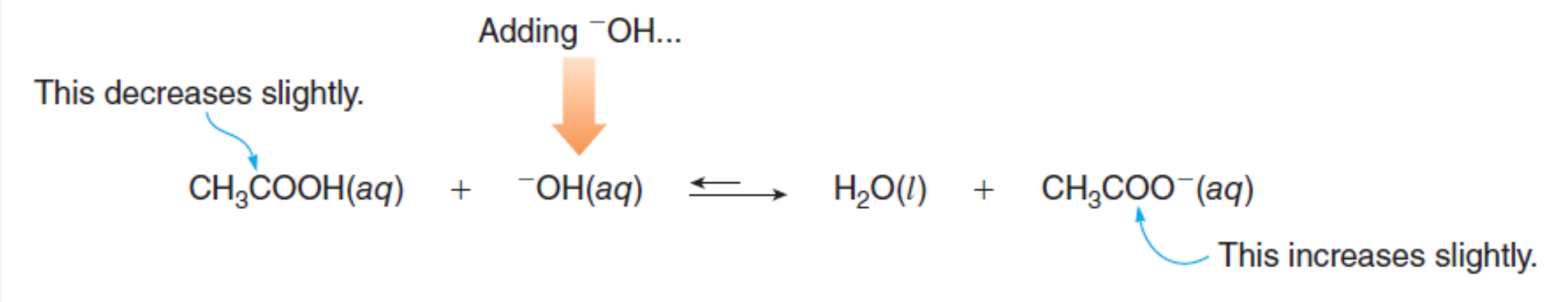

- In contrast, a buffer prepared from 0.50 M acetic acid ($CH_3COOH$) and 0.50 M sodium acetate ($NaCH_3COO$) has a pH of 4.74. Addition of the same quantity of acid, 0.020 mol HCl, changes the pH to 4.70, and addition of the same quantity of base, 0.020 mol of NaOH, changes the pH to 4.77. In this example, the change of pH in the presence of the buffer is no more than 0.04 pH units!

# Why is a buffer able to absorb acid or base with very little pH change?

- Let's use as an example a buffer that contains equal concentrations of acetic acid ($CH_3COOH$), and the sodium salt of its conjugate base, sodium acetate ($NaCH_3COO$). $CH_3COOH$ is a weak acid, so when it dissolves in water, only a small fraction dissociates to form its conjugate base $CH_3COO^-$. In the buffer solution, however, the sodium acetate provides an equal amount of the conjugate base.
- Suppose a small amount of strong acid is added to the buffer. Added $H_3O^+$ reacts with $CH_3COO^-$ to form $CH_3COOH$, so that $[CH_3COO^-]$ decreases slightly and $[CH_3COOH]$ increases slightly, but the $[H_3O^+]$ and therefore the pH change only slightly.



- On the other hand, if a small amount of strong base is added to the buffer, $^{-}OH$ reacts with $CH_3COOH$ to form $CH_3COO^{-}$, so that $[CH_3COOH]$ decreases slightly and $[CH_3COO^{-}]$ increases slightly but the $[H_3O^{+}]$ and therefore the pH change only slightly.



# PROBLEM

Determine whether a solution containing each of the following substances is a buffer. Explain your reasoning.

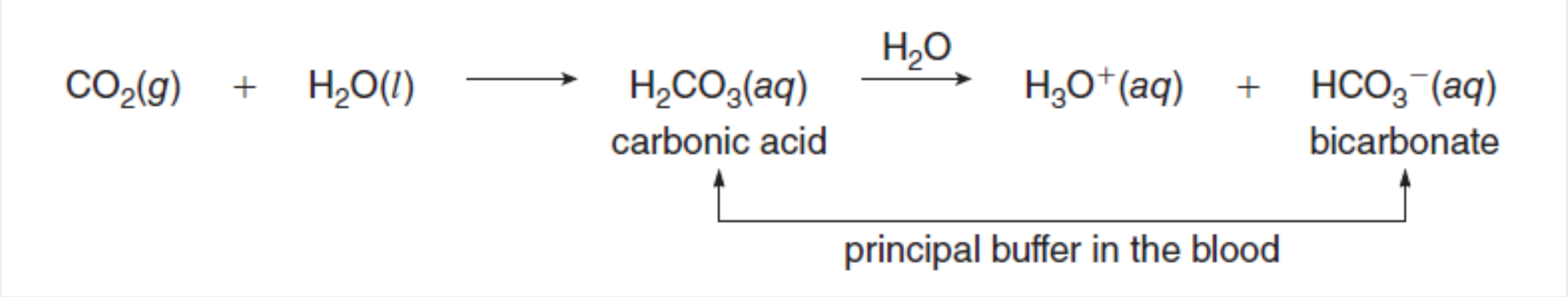
a. HBr and NaBr
b. HF and KF
c. $CH_3COOH$ alone

# 8. Buffers in the Blood

- **The normal blood pH** of a healthy individual is in the range of **7.35 to 7.45**. A pH above or below this range is generally indicative of an imbalance in **respiratory** or **metabolic** processes.
- The body is able to maintain a very stable pH because the blood and other tissues are buffered. The principal buffer in the blood is **carbonic acid/bicarbonate** ($H_2CO_3/HCO_3^-$).

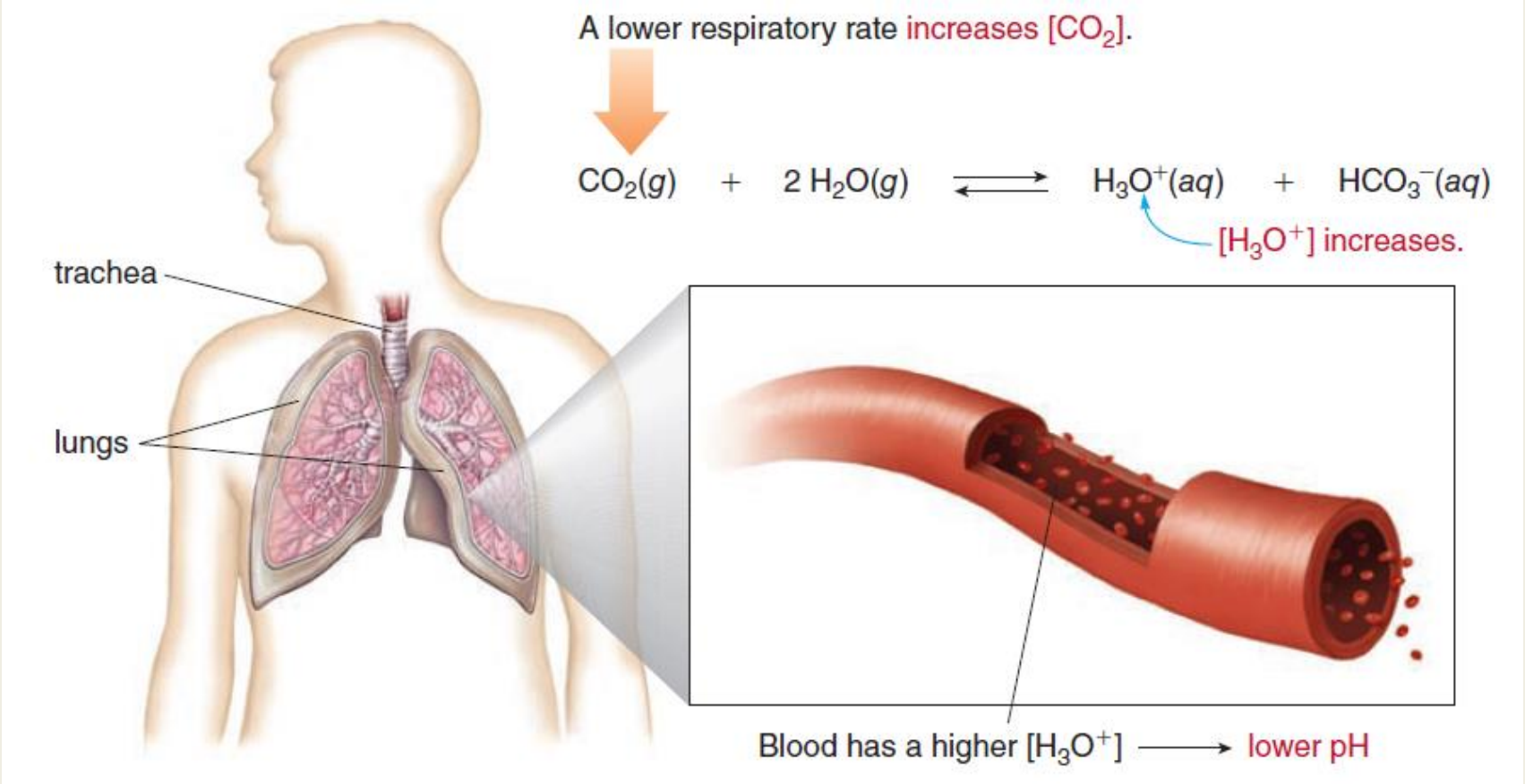
# 8. Buffers in the Blood

- In examining the carbonic acid/bicarbonate buffer system in the blood, two reactions are important. First of all, carbonic acid ($H_2CO_3$) is formed from $CO_2$ dissolved in the bloodstream. Second, since carbonic acid is a weak acid, it is also dissociated in water to form its conjugate base, bicarbonate ($HCO_3^-$). Bicarbonate is also generated in the kidneys.



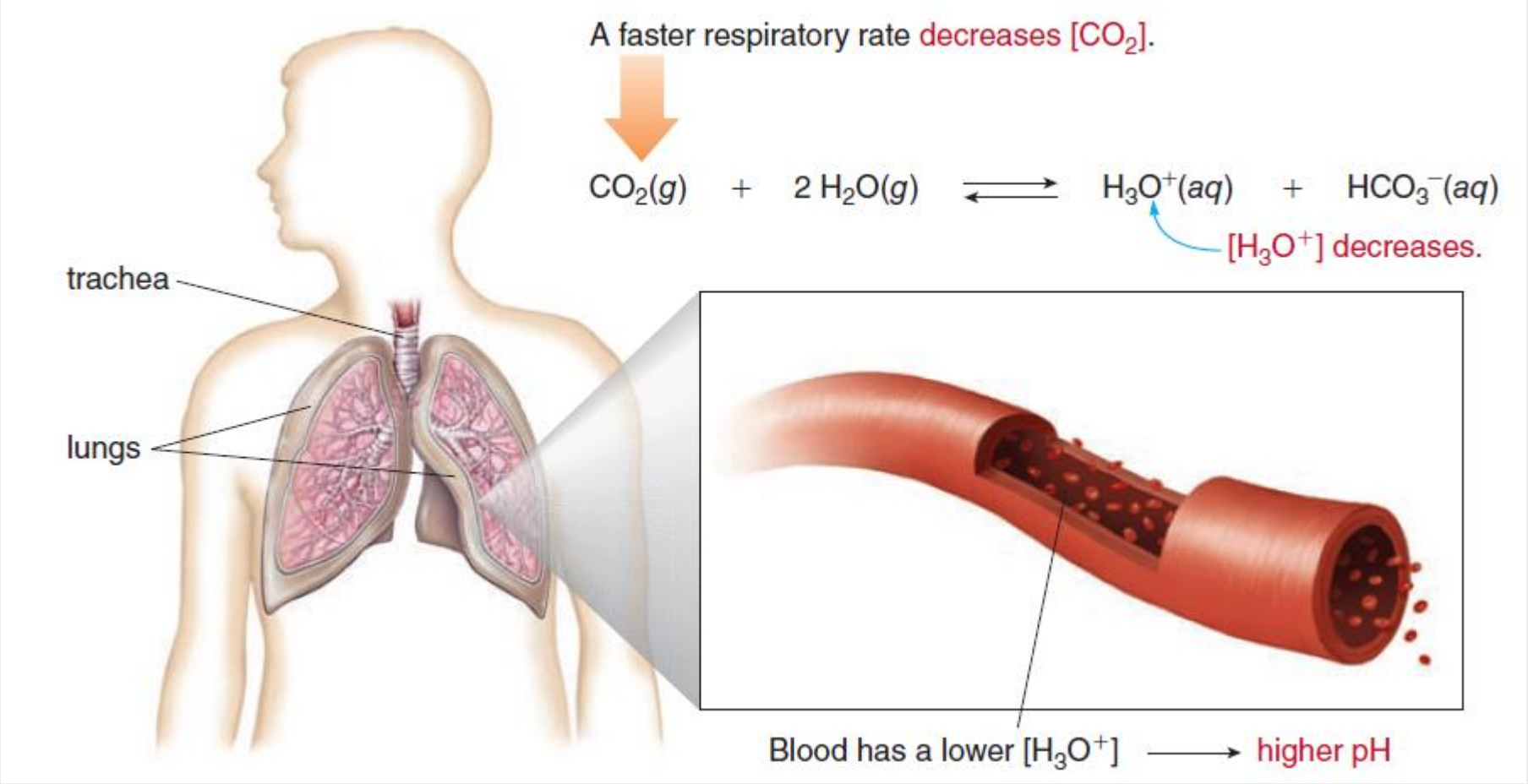
# 8A. Respiratory acidosis

- A higher-than-normal $CO_2$ concentration increases the $H_3O^+$ concentration and lowers the pH. **Respiratory acidosis** results when the body fails to eliminate adequate amounts of $CO_2$ through the lungs. This may occur in patients with advanced lung disease or respiratory failure.



# 8B. Respiratory alkalosis

- A lower-than-normal $CO_2$ concentration decreases the $H_3O^+$ concentration and raises the pH. **Respiratory alkalosis** is caused by **<u>hyperventilation</u>**, very rapid breathing that occurs when an individual experiences excitement or panic.



# Respiratory acidosis and alkalosis

- Respiratory acidosis is the most common type of acid-base imbalance
- Respiratory alkalosis is relatively rare

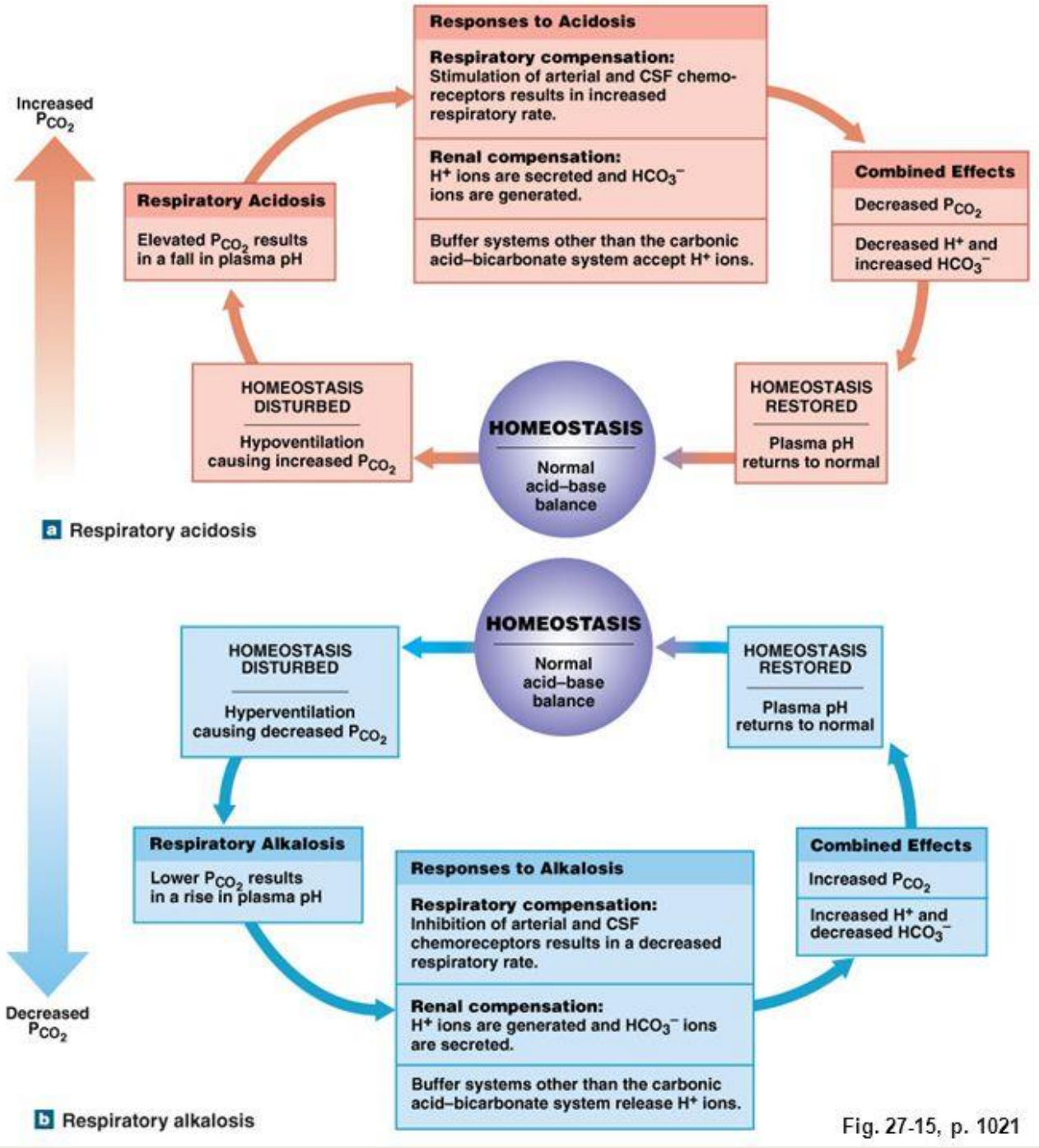



Fig. 27-15, p. 1021

# Buffers in the Blood

- The pH of the blood may also be altered when the metabolic processes of the body are not in balance.
- **Metabolic acidosis** results when excessive amounts of acid are produced and the blood pH falls. This may be observed in patients with severe infections (sepsis). It may also occur in poorly controlled diabetes.
- **Metabolic alkalosis** may occur when recurrent vomiting decreases the amount of acid in the stomach, thus causing a rise in pH.

*End*