

BENG 100 Frontiers of Biomedical Engineering
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Chapter 7

SUMMARY

- Engineering analysis requires definition of the system under study, which is accomplished by identifying system boundaries.
- Systems at steady state do not change appreciably with time.
- Internal respiration is the process by which cells obtain energy by oxidation of chemical compounds; external respiration is the process of exchange of oxygen with the external environment, which is accomplished by the lungs.
- Hemoglobin allows blood to carry substantial quantities of oxygen, despite the low solubility of oxygen in water.
- Carbon dioxide dissolved in water forms carbonic acid, which dissociates to bicarbonate and hydrogen ions; the bicarbonate/carbon dioxide system is the primary mechanism for buffering to stabilize against changes in pH in the body.
- The digestive system is responsible for digestion of food into its molecular components, and absorption of nutrients into the body.
- The chemical reactions of digestion can be understood in terms of mathematical models of chemical reactors.

KEY CONCEPTS AND DEFINITIONS

alveolus (*pl.* alveoli) - one of the terminal sac-like dilations of the alveolar ducts in the lung.

alveolar duct – the part of the respiratory passage beyond the bronchioles from which alveolar sacs and alveoli arise.

assumption – a proposition that is treated for the sake of a given discussion as if it were known to be true.

bronchiole – a minute branch into which the bronchus divides, which lack cartilage.

bronchus (*pl.* bronchi) - one of the subdivisions of the trachea, serving to carry air to and from the lungs.

capacities – a term used to describe the maximum amount that a system (e.g. lungs) can contain.

carbonic anhydrase – an enzyme that catalyses the interconversion of carbon dioxide and water to form carbonic acid, bicarbonate ions and protons (H^+).

continuously stirred tank reactor (CSTR) – a reactor model used to estimate the key unit operation variables when using a continuously agitated-tank reactor or a reactor whose contents are well mixed, in order to reach a specified output.

dead space – the air that is inhaled by the body but does not partake in gaseous exchange.

equilibrium – a state in which opposing or influencing forces are perfectly balanced.

expiration – Exhalation, the release of gases from the lung.

external respiration – the bodily process of inhalation and exhalation; the process of taking in oxygen from inhaled air and releasing carbon dioxide by exhalation.

fick's laws – a set of laws that describe diffusion and define the diffusion coefficient.

homeostasis – the ability or tendency of living organisms (or open systems in general) to maintain stable internal environment by adjusting its physiological processes.

ideal reactor model – a model reactor that is used to describe a system and its boundaries.

inspiration – inhalation, intake of gases by the lungs.

internal respiration - the metabolic processes whereby certain organisms obtain energy from organic molecules; processes that take place in the cells and tissues during which energy is released and carbon dioxide is produced and absorbed by the blood to be transported to the lung.

intrapleural – a term that refers to a location within the pleura, either the covering of the lungs (visceral pleura) or of the inner surface of the chest wall (parietal pleura).

mass (or material) balance – a method of accounting of material entering and leaving a system based on the conservation of mass principle where matter cannot be created nor destroyed.

mathematical model – this is an abstract model that uses mathematical language to describe the behavior of a system.

observation – a specified behavior or event as seen in reality; an actual or real event.

partial pressure – the pressure that would be exerted by one of the gases in a mixture if it is occupied the same volume of its own.

plug flow reactor (PFR) – a model reactor used to estimate the key unit operation variables when using a continuous tubular reactor or a reactor in which contents move in a flowstream in order to reach a specified output.

prediction – the forecast of a specified behavior of a system based on underlying assumptions.

rate constant – a constant of proportionality that relates the rate of a chemical reaction at a given temperature to the concentration of reactants or products.

resistance – a measure of the degree to which flow of a substance (e.g. fluid or current) is hindered.

respiratory bronchiole - the smallest portion of the bronchiole connecting the terminal bronchiole to the alveolus.

respiratory membrane – a thin epithelial layer of squamous cells that contains fluid lining the alveolus.

saturated – the fraction of total protein binding sites that are occupied at any given time.

spirometer – a gas meter used for measuring respiratory gases

steady state – an unvarying condition (i.e. all state variables are constant) in spite of ongoing conditions to change that state.

system – a set of interconnected parts that come together to form a complete whole e.g. the excretory system.

system boundaries – the physical sites of intersection between the system under study and the external environment.

terminal bronchiole – the last portion of the bronchiole before it subdivides into respiratory bronchioles.

tidal volume – the volume of air inhaled and exhaled at each normal breath.

tracer – a substance introduced into a biological organism or other system so that its subsequent distribution can be followed from its color, fluorescence, radioactivity or other distinctive properties.

trachea – a large membranous tube supported by rings of cartilage extending from the larynx to the bronchial tubes conveying air from and to the lungs; the windpipe

ventilation – replacement of air (or other gases) with air (or other gases)

QUESTIONS

1. Give three examples of biochemical reactions in the body that produce water.
2. Why do you think that physiologists defined a new parameter, the diffusing capacity D_L , to describe diffusion through the respiratory membrane, instead of using the physical parameters listed in Equation 7-22?
3. Cholera is a pathogen that infects the intestine, producing a toxin that blocks one of the G proteins (preventing normal cycling), and locks a Cl channel open (the same channel that is involved in cystic fibrosis: CFTR channel). Water reabsorption is severely impaired. Patients die of dehydration, sometimes losing L of fluid within a few hours. Why would blockage of an ion channel effect water reabsorption?