TOPIC 3. RESPIRATORY SYSTEM FUNCTIONS

Respiration includes both the physical exchange of oxygen and carbon dioxide between the lung surfaces and the atmosphere, called external respiration, and the chemical exchange of O_2 and CO_2 in cellular metabolism, called internal respiration. External respiration rates are rather easily measured, and changes in the gaseous composition of inhaled and exhaled air indicate the amounts of physical exchange of oxygen and carbon dioxide that has taken place. External respiration also includes changes in the vapor pressure of respired air which is part of the overall heat exchange and thermal energy balance of an organism. Internal respiration is necessary for tissue metabolism, and exothermic metabolic reactions are also involved in the thermal energy balance of an organism.

External respiration involves physical work, which can be accomplished only with the support of internal respiration and muscle contraction. Thus external and internal respiration are both essential and continuous functions for the maintenance of life itself, and both are part of the overall energy metabolism and heat exchange of organisms.

UNIT 3.1: EXTERNAL RESPIRATION

The mechanical movement of air from the atmosphere into the lungs and back to the atmosphere requires the expenditure of energy by the muscles involved in external respiration. The cost of breathing has been determined for man, and is 1.2% of the total oxygen consumption when at rest (Otis 1954). As activity and external respiration increase, the cost may double, and in very heavy respiration, may reach about four times the cost at rest, or nearly 5% of the total oxygen consumed. Margaria et al. (1960) determined a maximum of 3% of the total cost during exercise.

Respiration rates of wild ruminants are largely unknown. Generally younger animals have faster respiration rates than older animals of the same species. Larger animals, both of the same and different species, tend to have slower respiration rates than smaller ones. Respiration rates increase with increases in the amount of physical activity as more oxygen is needed to support higher rates of metabolism. The respiratory frequency of reindeer in lying posture was 23 and in standing posture 36 per minute (White and Yousef 1978).

Respiration rates are regulated by the CO_2 concentration in the blood; as the CO_2 concentration increases, the rate and volume of external respiration increases. It is interesting that, while increased activity results in an increased need for oxygen, it is not the need for oxygen but rather the increased CO_2 in the blood from increased internal resiration that stimulates pulmonary ventilation. This can be demonstated by increasing the CO_2 concentration of inhaled air, and observing an increase in the respiration rate and volume even without an actual increased energy expenditure.

A few measurements of external respiration rates have been made, usually as part of metabolism studies, and may be used to formulate a general pattern of changes in relation to age, size, and activity. Changes also occur with season as metabolic changes occur; measurements of external pulmonary ventilation rates should be made over the entire annual cycle. Superimposed on these predictable changes are the effects of transient stimuli. These changes occur in relation to fright responses, apprehension, etc. In general, transient changes in external respiration are expected to be related to changes in activity and metabolism due to overt responses.

LITERATURE CITED

Margaria, R., G. Milic-Emili, J. M. Petit, and G. Cavogua. 1960. Mechanical work of breathing during muscular exercise. J. Appl. Physiology 15:354-358.

Otis, A. B. 1954. The work of breathing. Physiol. Rev. 34:449-458.

White, R. G. and M. K. Yousef. 1978. Energy expenditure of reindeer walking of roads and on tundra. Canadian J. Zool. 56(2):215-223.

REFERENCES, UNIT 3.1

EXTERNAL RESPIRATION

SERIALS

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS	AUTHORS	YEAR
JAPYA	15--3	354	358		mecha work, breath, mus ex	margaria,r; mili/	1960
PHREA	34--3	449	458		the work of breathing	otis,ab	1954

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS	AUTHORS	YEAR
				odvi			

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS	AUTHORS	YEAR
				odhe			

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS	AUTHORS	YEAR
CBCPA	61A--	43	48	ceel	oxygen util by elk calves	robbins,ct; cohe/	1977
JOMAA	49-4	762	764	ceel	physiolo studies, rocky mt	herin,ra	1968
JWMAA	43--2	445	453	ceel	energy expenditure, calves	robbins,ct; cohe/	1979
RSPYA	29--2	225	230	ceel	select oxygen transp param	mckean,t; staube/	1977

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS	AUTHORS	YEAR
				alal			

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS	AUTHORS	YEAR
				rata			

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS	AUTHORS	YEAR
				anam			

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS	AUTHORS	YEAR
RSPYA	30--3	305	310	bibi	blood respirato properties	haines,h; chiche/	1977

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS	AUTHORS	YEAR
				ovca			

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS	AUTHORS	YEAR
				ovda			

CODEN VO-NU BEPA ENPA ANIM KEY WORDS---------- AUTHORS---------- YEAR

obmo

CODEN VO-NU BEPA ENPA ANIM KEY WORDS---------- AUTHORS---------- YEAR

oram

CODEN VO-NU BEPA ENPA ANIM KEY WORDS---------- AUTHORS---------- YEAR

ATRLA 12--- 349 360 bibo physiological properties janusz,g 1967

UNIT 3.2: INTERNAL RESPIRATION

Internal respiration, or the exchange of gases between the lung surfaces and the blood is based on pressure differences between the blood and the lung surfaces, and the O_2 and CO_2 is exchanged by diffusion at rates dependent on the difference in pressure between capillary blood and the gas at the respiratory surface.

Blood increases in oxygen upon exposure to respiratory surfaces. Blood contains both plasma and cells, but the solubility of O_2 is low in plasma, so nearly all of the O_2 carried by the blood is associated with the red cells. These cells contain the pigment hemoglobin, which is chemically composed of a protein "globin" and four "heme" groups. The iron-containing heme groups function in oxygen transport, and oxygen molecules (4) unite with the four iron atoms to form a fully-saturated oxyhemoglobin molecule. This is the basis for very efficient oxygen transport in the vascular system.

Muscles are active sites of oxidative metabolism, and they contain a particular kind of hemoglobin called myoglobin which has a greater oxygen affinity than hemoglobin. It is likely that the pigment myoglobin facilitates oxygen diffusions to the mitochondria in muscle cells (White, p. 195 in Gordon 1977).

LITERATURE CITED

Gordon, M. S. 1977. Animal physiology: principles and adaptations. Macmillan Publishing Co., Inc., N.Y. 699 pp.

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INTERNAL RESPIRATION

SERIALS

CODEN VO-NU BEPA ENPA ANIM KEY WORDS---------- AUTHORS---------- YEAR

odvi

CODEN VO-NU BEPA ENPA ANIM KEY WORDS---------- AUTHORS---------- YEAR

odhe

CODEN VO-NU BEPA ENPA ANIM KEY WORDS---------- AUTHORS---------- YEAR

RSPYA 29--2 225 230 ceel select oxygen transp param mckean,t; staube/ 1977

CODEN VO-NU BEPA ENPA ANIM KEY WORDS---------- AUTHORS---------- YEAR

alal

CODEN VO-NU BEPA ENPA ANIM KEY WORDS---------- AUTHORS---------- YEAR

rata

CODEN VO-NU BEPA ENPA ANIM KEY WORDS---------- AUTHORS---------- YEAR

anam

CODEN VO-NU BEPA ENPA ANIM KEY WORDS---------- AUTHORS---------- YEAR

RSPYA 30--3 305 310 bibi blood respirato properties haines,h; chiche/ 1977

CODEN VO-NU BEPA ENPA ANIM KEY WORDS---------- AUTHORS---------- YEAR

ovca

CODEN VO-NU BEPA ENPA ANIM KEY WORDS---------- AUTHORS---------- YEAR

ovda

CODEN VO-NU BEPA ENPA ANIM KEY WORDS---------- AUTHORS---------- YEAR

obmo

CODEN VO-NU BEPA ENPA ANIM KEY WORDS---------- AUTHORS---------- YEAR

oram