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Abstract

The results obtained in this investigation may be summarized as follows : 1. The CO2-output of the male muscle and other tissues is greater than that of the female. 2. The female muscle contains larger amount of water than the female muscle. 3. The muscle immersed 1/2 Ringer solution (or 1/2.5 R.) gave out smaller amount of CO2 per minute than the muscle in 2-Ringer's solution (or 2.5 R.). In spite of the difference in the water content of tissue between different sex, the salt content of the tissue liquid seems to be the same. In other words, larger the water content means larger content of tissue liquid in the tissue. Artificial introduction of water in the tissue or reduction of water content by immersing the tissue in 1/2 or 2-Ringer's solution is quite different from the natural condition occurring between different sex. However both of these conditions influence the gaseous metabolism in the same manner. On an assumption that the gas diffusion in liquid is proportional to the solubility of that gas, the above mentioned difference of CO2-output should be just reversed. Therefore it is not possible to interpret how the water content influences the gaseous metabolism. It may only be stated that the muscle which has a small amount of water to an extent which does not abolish excitability, gives out much CO2 and vice versa.

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On the Difference of the CO_2-output of the Frog's Tissue between Different Sex.

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It has been shown by numerous investigators that there is a difference in the rate of gaseous metabolism between the male and female. The average CO_2-output per minute by the males is greater than that of the females. The literature on the subject are so well-known that it is hardly be necessary to enumerate them. In this investigation, some experiments in regard to the following questions were carried out:

(1) the difference of the CO_2-output per min. and per gram of the frog's tissues from different sex; (2) the difference of water-content of frog's tissues between different sex.

Experimental.

1) CO_2-output of the frog's tissues.

Estimation of carbon-dioxide was made by *Parker*'s method as follow: four *Parker*'s respiration tubes of hard glass fitted with cork-stopper were used for the experiment. A small piece (ca. 0.05 g) of excised tissue to be tested, was tied on the bamboo-rods which were thrusted into the tubes (one end of rod was sticked into the stopper). These respiration tubes were filled to about one third of tube with 0.0001 mol. sodium bicarbonate-solution, tinged with phenol red, whose reaction were brought exactly to pH 7.8 by passing pure oxygen-gas. Two tubes which contained solution of pH 7.8 (red-purple)[1] and 7.4 (yellow-red)[2] tinged with phenol red arranged in

1) Solution of pH 7.8 = 1.6 cc of 0.2 mol. boracic acid solution + 0.4 cc of 0.05 mol. borax solution + two drops of phenol red.
2) Solution of pH 7.4 = 1.8 cc of 0.2 mol. boracic acid solution + 0.2 cc of 0.05 mol. borax solution + two drops of phenol red.

one row with respiration tubes in wooden frame to compare the change of colour. This wooden frame hinged to a stand and gently moved to and fro by means of an electric motor to facilitate the dissolution of CO_2 given out by living tissue, into the bicarbonate solution. Tinge of phenol red shows exactly when the bicarbonate solution reached to pH 7.4 and 1.0 cc of 0.0001 mol. sodium bicarbonate solution changes that reaction from pH 7.8 to 7.4 with 0.00066 mg of CO_2. By noting the time necessary to change from pH 7.8 to 7.4, the rate of gaseous metabolism is determined. The rate of metabolism may be calculated after following formula.

$$X = \frac{0.00066 \times (\text{Volum of sodium bicarbonate solution} + \text{air space in respiration tube})}{t \times G}$$

t · · · time taken to change pH of bicarbonate solution from 7.8 to 7.4.

G · · weight of tissue.

The results are given in Table 1 and 2.

Table 1. CO_2-output of the Frog's Sartorius.

Date	Temp. (C°)	No. of frog	Sex	Weight of sartorius	Capacity of respiratory tube (cc)	Required time (min.)	$NaHCO_3$-solution (mol.)	CO_2-output per g. per min. (mg)	Remarks
3/March	11°	1	♂♀	71	12.5	27	0.0001	0.0043	
„	„	2	♀	48	„	64	„	0.0027	
6/March	11°	3	♂	43	6.5	29	0.0001	0.0034	On the same frog
			♂	42	„	26	„	0.0039	
„	„	4	♂	34	„	41	„	0.0030	„
			♀	30	„	48	„	0.0029	
„	„	5	♂	86	„	15	„	0.0033	„
			♂	68	„	20	„	0.0031	
„	„	6	♂	74	„	29	„	0.0020	„
			♀	67	„	31	„	0.0020	
7/March	9°	7	♂	42	„	39	„	0.0026	„
			♂	42	„	41	„	0.0024	
„	„	8	♀	33	„	56	„	0.0023	„
			♀	31	„	58	„	0.0023	
„	10°	9	♂	45	„	37	„	0.0025	„
			♂	49	„	35	„	0.0025	
„	11°	10	♀	53	„	38	„	0.0021	„
			♀	52	„	39	„	0.0021	
„	12°	11	♂	35	„	45	„	0.0027	„
			♂	36	„	44	„	0.0027	
„	„	12	♀	32	„	57	„	0.0023	

The average CO_2-output { ♂ · · 0.0030 ; ♀ · · 0.0023

Table 2. CO_2-output of the Frog's Tissues.

Date	Temp. (°C)	Sex	Materials (mg)	Capacity of respiratory tube (cc)	Required time (min.)	$NaHCO_3$-solution (mol.)	CO_2-output per g. per min. (mg)	Remarks
			kidney					
13/March	16°	♀	63	12.5	25	0.0001	0.0052	
„	„	♂	37	„	38	„	0.0058	
„	17°	♀	77	„	27	„	0.0039	
14/March	13°	♀	35	12.5	44	0.0001	0.0053	
„	16°	♀	32	„	41	„	0.0062	
„	„	♂	29	„	46	„	0.0064	
			liver					
13/March	16°	♀	254	12.5	15	0.0001	0.0020	
„	17°	♂	78	„	18	„	0.0058	
„	„	♀	186	„	21	„	0.0021	
14/March	13°	♀	99	„	40	„	0.0020	
„	„	♂	90	„	21	„	0.0043	
			ischiatic N.					
16/March	16°	♀	34	6.5	33	0.0001	0.0038	
„	„	♀	34	„	36	„	0.0035	
„	„	♂	26	„	31	„	0.0053	
„	„	♂	26	„	35	„	0.0046	
„	„	♂	43	„	17	„	0.0053	

2) Relation of the change of the gaseous metabolism to the water content of tissue.

In order to change the water content of dissected tissue, it was in the double concentrated and half-concentrated *Ringer*'s. After 10 to 20 minuts assuming the balance attained between tissue and surrounding liquid, began the peperiment as previously mentioned.

The results are shown in Table 3 and 4.

Table 3. Gaseous Metobolism and the Water Content of Tissues.

Date	Temp. (°C)	Preparations (put in Ringer's solution) (min)	Sex	Weight of material (mg)	Capacity of respiratory tube (cc)	Required time (min.)	$NaHCO_3$-solution (mol.)	CO_2-output per g per min. (mg)	Remarks
13/March	14°	2×R (10′)	♂	sartorius 47	6.5	14	0.0001	0.0065	On the same muscle
,,	,,	R	♂	sartorius ,,	,,	27	,,	0.0033	On the same frog
,,	,,	R	♂	sartorius 47	,,	25	,,	0.0036	
,,	,,	2×R (10′)	♀	sartorius 63	,,	15	,,	0.0045	,,
,,	,,	R	♀	sartorius 86	,,	18	,,	0.0027	
18/March	13°	R	♂	kidney 32	,,	22	,,	0.0061	,,
,,	,,	2×R (10′)	♂	kidney 22	,,	24	,,	0.0081	
19/March	17°	R	♀	kidney 37	12.5	179	0.001	0.0081	,,
,,	,,	2×R (10′)	♀	kidney 43	,,	101	,,	0.0118	
,,	15°	R	♀	sartorius 37	,,	179	,,	0.0080	,,
,,	,,	2×R (15′)	♀	sartorius 43	,,	101	,,	0.0122	
20/March	14°	R	♂	kidney 32	,,	209	,,	0.0079	,,
,,	,,	2×R (10′)	♂	kidney 34	,,	168	,,	0.0092	
30/March	13°	3×R (10′)	♂	sartorius 68	,,	78	,,	0.0100	,,
,,	,,	R	♂	sartorius 73	,,	132	,,	0.0055	
17/April	18°	2.5×R (10′)	♀	sartorius 45	,,	72	,,	0.0164	,,
,,	,,	R	♀	sartorius 51	,,	78	,,	0.0133	
,,	,,	2.5×R (20′)	♀	sartorius 83	,,	44	,,	0.0144	,,
,,	,,	R	♀	sartorius 80	,,	74	,,	0.0069	
22/April	18°	2.5×R (10′)	♂	sartorius 54	,,	28	0.0055	0.0181	,,
,,	,,	R	♂	sartorius 76	,,	60	,,	0.0060	

Notes: R · · standard Ringer's solution. 2×R · · double R.

Table 4. Gaseous Metabolism and the Water Content of Tissues.

Date	Temp. (°C)	Preparations (put in Ringer's solution) (min.)	Sex	Weight of material (mg)	Capacity of respiratory tube (cc)	Required time (min.)	$NaHCO_3$-solution (mol.)	CO_2-output per g per min. (mg)	Remarks
22/March	16°	R	♂	ischiadic n. 28	6.5	59	0.0001	0.0025	On the same frog
„	„	1/2 R (10′)	♂	ischiadic n. 23	„	94	„	0.0019	
„	16.5°	R	♀	kidney 43	„	19	„	0.0052	„
„	„	1/2 R (20′)	♀	kidney 43	„	28	„	0.0035	
„	„	R	♂	sartorius 67	„	20	„	0.0032	„
„	„	1/2 R (20′)	♂	sartorius 71	„	22	„	0.0027	
„	„	R	♂	kidney 44	„	21	„	0.0046	„
„	„	1/2 R (15′)	♂	kidney 48	„	29	„	0.0030	
24/March	12°	R	♀	sartorius 77	12.5	24	„	0.0044	„
„	„	1/2 R	♀	sartorius 86	„	34	„	0.0028	
14/April	11°	1/2.5 R (20′)	♂	sartorius 100	6.5	150	0.001	0.0018	„
„	„	R	♂	sartorius 65	„	108	„	0.0039	
„	„	1/2.5 R	♂	sartorius 80	12.5	185	„	0.0035	„
„	„	R	♂	sartorius 72	„	120	„	0.0061	
21/April	15°	R	♂	sartorius 42	6.5	38	0.0055	0.0089	„
„	„	1/2.5 R	♂	sartorius 55	„	67	„	0.0036	
23/April	17°	R	♂	sartorius 66	12.5	60	„	0.0071	„
„	„	1/2.5 R	♂	sartorius 73	„	133	„	0.0028	
25/April	18°	R	♂	sartorius 76	„	54	„	0.0065	„
„	„	1/2.5 R	♂	sartorius 85	„	103	„	0.0031	

Note: 1/2 R · · half Ringer's solution.

3) The estimation of the water content in frog's sartorius.

The quantitative determination of the amount of water contained in the frog's sartorius was carried out as follows. Soon after the

Table 5. The Amount of Water Content of Frog's Sartorius between Different Sex.

Date	Temp. (°C)	♂ Sartorius + watch glass (contains H_2O) (g)	♂ Sartorius + watch glass (anhydrous) (g)	♂ Dry weight (g)	♂ Water (%)	♀ Sartorius + watch glass (contains H_2O) (g)	♀ Sartorius + watch glass (anhydrous) (g)	♀ Dry weight (g)	♀ Water (%)
30/March	14°					44.2514 sartorius (0.0911)	44.1752	0.0762	83.64%
						38.2825 sartorius (0.0810)	38.2148	0.0677	83.58%
1/April	14.5°	44.2195 sartorius (0.0592)	44.1721	0.0474	80.06%				
		38.2550 sartorius (0.0557)	38.2095	0.0455	81.68%				
3/April	14°	38.2651 sartorius (0.0633)	38.2138	0.0513	81.04%				
		44.2281 sartorius (0.0666)	44.1763	0.0518	77.77%				
6/April						44.2015 sartorius (0.0400)	44.1695	0.0320	80.00%
						38.2439 sartorius (0.0421)	38.2103	0.0336	79.81%
8/April	16°	44.2402 sartorius(b) (0.0787)	44.1762	0.0640	83.86%	38.2776 sartorius(b) (0.758)	38.2139	0.0637	84.03%
10/April	17°	44.2412 sartorius(b) (0.0797)	44.1756	0.0656	82.30%	38.3151 sartorius(b) (0.1133)	38.2215	0.0936	82.61%
		Average H_2O %			♂ 81.11%		:		♀ 82.27%

sartorius was excised, it was held between 2 watch glasses and weigh accurately, and the sartoius was exposed to the sun to dry, then placed in a thermostat with gas-regulator and heat gently to 100°C which was kept over one hour. After cooling in a desiccator, weighed accurately, until the constant weight was reached.

As the following table shows, the female muscle contained a slightly larger amount of water than the muscle from the male. (Table 5).

Summary and conclusion.

The results obtained in this investigation may be summarized as follows:

1. The CO_2-output of the male muscle and other tissues is greater than that of the female.

2. The female muscle contains larger amount of water than the female muscle.

3. The muscle immersed 1/2 Ringer solution (or 1/2.5 R.) gave out smaller amount of CO_2 per minute than the muscle in 2-Ringer's solution (or 2.5 R.).

In spite of the difference in the water content of tissue between different sex, the salt content of the tissue liquid seems to be the same. In other words, larger the water content means larger content of tissue liquid in the tissue. Artificial introduction of water in the tissue or reduction of water content by immersing the tissue in 1/2 or 2-Ringer's solution is quite different from the natural condition occurring between different sex. However both of these conditions influence the gaseous metabolism in the same manner. On an assumption that the gas diffusion in liquid is proportional to the solubility of that gas, the above mentioned difference of CO_2-output should be just reversed. Therefore it is not possible to interpret how the water content influences the gaseous metabolism. It may only be stated that the muscle which has a small amount of water to an extent which does not abolish excitability, gives out much CO_2 and vice versa.

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Refereces.

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