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Condensed Chromatin, Cell Thermoregulation and Human Body Heat Conductivity

A.I. Ibraimov and S.K. Tabaldiev

Laboratory of Human Genetics, National Center of Cardiology and Internal Medicine,
Togolok Moldo str., 3, Bishkek, 720040, Kyrghyzstan

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ABSTRACT Earlier we put out a proposal on possible participation of condensed chromatin (CC) in cell thermoregulation; CC being the densest domain in a cell, apparently conducts heat between the cytoplasm and nucleus when there is difference in temperature between them. This hypothesis can be checked at the level of cells or organisms. Experimentally we have managed to establish that at the level of organisms there is a broad intra population variability of human body heat conductivity (BHC). It is shown that these individual differences in the BHC are attributed to the amount of chromosomal Q-heterochromatin regions (Q-HRs) in their genome. It is assumed that, possibly, the biological role of the Q-HRs in the interphase nucleus of the cell is in intensification of the CC compacting thus increasing its heat conductivity (HC). On the HC of CC, correspondently on the amount of Q-HRs in the genome, depends the speed of leveling the difference of temperature between the cytoplasm and nucleus, i.e. the cell thermoregulation. From the HC of the cells the HC of the whole body is made up. This is a physical condition, where the physiological thermoregulation is realized, which is assigned for keeping relative temperature constancy in the inner medium of the organism by leveling the temperature difference in different parts of the body.

INTRODUCTION

Assumption on a possible heat conductive effect of condensed chromatin (CC) between the nucleus and cytoplasm in the interphase cell (Ibraimov, 2003) needs an experimental testing. In the economic conditions of the post-soviet Kyrghyzstan it is impossible to check this hypothesis at the cell level. However it is still possible to carry out some experimental researches at the organism level using simple technical facilities.

Apparently, if the CC really has a heat conductive effect at the cell level, then the same physical effect should also be manifested at the level of a whole organism. For example, when the temperature of a certain part of a body is higher or lower than the physiological optimum for this species, the organism strives to liquidate this difference as soon as possible in order to keep a relative constancy of its inner temperature – temperature homeostasis. For this the homoiothermal organisms, to which *Homo sapiens* relates, use the whole system of physiological thermoregulation: the central (hypothalamus) and periphery (thermo receptors) nerve; circulating through the whole body liquids, such as blood and lymph for distant transport of heat energy; vascular reactions (constriction or dilation of the blood vessels for regulation of the heat flow, transported by the blood and lymph); heat production and heat loss.

It is commonly assumed that the main elements of the organ-based physiological thermoregulation are known, and at present the efforts are directed at the study of their complex interactions at the cell and molecular level (Blatties, 1997). However our long experience of studying the effects of one of the types of constitutive heterochromatin in the human genome – chromosomal Q-heterochromatin regions (Q-HRs) – inclines to the idea that, possibly, in the process of keeping the temperature homeostasis in the organism one more element participates – that is the heat conductivity of the cellular part of a body (BHC) (Ibraimov, 2003, 2004). This assumption may be valid if it turns out that: (1) the individuals in the population will significantly differ from each other by BHC, and (2) intra population human variability by BHC is connected with the amount of Q-HRs in his genome.

MATERIALS AND METHODS

The research was carried out with youths and girls from 18 to 23 years old. They represented three race–ethnic groups: the Kyrghyz and Russians permanently living in Kyrghyzstan, and individuals who have arrived from three northern states of India (Uttar Pradesh, Bihar and Punjab) (Ibraimov et al., 1997). All of them are the students of the Kyrghyz State Medical Academy in Bishkek. At the date of the research none of them complained about the increase of the body temperature, common cold, or menses.

Physiological Methods

For indirect assessment of the BHC the left arm (up to the wrist) of the person being investigated was submerged for 20 minutes in a vacuum flask filled either with "hot" (40.0°C), or "cold" (15.0°C) water, and every 5 minutes the temperature of water was measured by a laboratory mercurial thermometer to within 0.1 Celsius (t°C). At first we measured, as we conventionally call it, the "volume of the hand". For this purpose we slowly submerged the left hand of the person under study into the vessel full to the brim with water. Under this vessel there was an empty vessel in which the water displaced by the hand of the person being investigated poured out. The volume of this water was measured in *cm³*, and conventionally it was called the "volume of the hand" (VH). When assessment of the BHC was carried out with "hot water", soon after submerging of the hand up to the wrist, a teaspoon of refined vegetable oil was poured out on the surface of water to decrease its evaporation. In order to protect the temperature of water from the influence of the room temperature we use a customary vacuum-flask for keeping hot meals with volume of 2000 ml, and permanently filled it with 1500 ml of "hot" or "cold" water. No other additional measures were taken for protection from the impact of temperature of the room where the tests were carried out.

The person is to sit erect, the arms hanging naturally at the sides, head somewhat elevated, but muscular rigidity should be carefully avoided. Then the person being investigated was asked to slowly submerge the left arm up to the wrist (up to the point where the VH was determined) into the water, without diverting attention, and not to press the wrists to the sides of the vacuum-flask and keep them only in water. In addition to the passport information on all persons, their weight and height was measured. For ease of numerical results analysis of the experiments, in measurements, when the mercury column level coincided with the odd point of the thermometer, its values were underrated by one-tenth (0.1) degree to obtain an even number. For example, when the thermometer showed 1.5°C, this figure was recorded as 1.4°C

Cytogenetic Methods

Chromosomal preparations were made using short-term cultures of peripheral blood lymphocytes. The cultures were processed according to slightly modified (Ibraimov, 1983) conventional methods (Hungerford, 1965). The dye used was propylquinacrine mustard. Calculation and registration of chromosomal Q-HRs was performed using criteria and methods described in detail elsewhere (Ibraimov et al., 1982; 1990).

The χ^2 test was used to compare distributions of Q-HRs in Table 10. The mean numbers of Q-HRs per individual and mean numbers of change of the water temperature (t°C) were compared using the Student t-test.

RESULTS

In Tables 1-3 the data obtained from the tests with the Kyrghyz, Russians and Indians when submerging their hands in "hot" water are presented. It was done to indirectly assess the BHC through ability of the examined individuals to lower the t°C of water when the t°C of this water is higher than the normal core temperature of a human organism. For more complete account of the VH influence on the results of the tests, the studied individuals were conventionally split up into 3 groups: group I was comprised of the individuals whose VH did not exceed 349 cm³, group II - from 350 to 399 cm³, group III - from 400 cm³ and more.

Analysis of the obtained data shows that: (1) there is a wide range of variability in the studied individuals concerning their ability to lower the t°C of "hot" water (from 1°C to 5°C); (2) on average the Kyrghyz have the worst ability to lower the t°C of "hot" water, the Russians lower the t°C of water better than the Kyrghyz, but worse than the Indians; (3) male persons demonstrate the greatest range of variability concerning their ability to lower the t°C of water irrespective their race-ethnical peculiarities.

In Tables 4-6 the data obtained from the tests with the Kyrghyz, Russians and Indians when submerging their hands in "cold" water are

Table 1: Lowering of "hot" (40^{o}C) water temperature (in ^{o}C) by youths and girls of the Kyrghyz nationality.

Lowering of water tempera ture (in ^{o}C)	*Men*			*Women*	*Total*	
	*I**	*II*	*III*	*I*	*Men*	*Women*
1						
1,2						
1,4	1				1	
1,6						
1,8						
2				4		4
2,2	1			4	1	4
2,4	2	1		6	3	6
2,6	3		1	11	4	11
2,8	2	3	1	9	6	9
3	2	2	3	12	7	12
3,2	2	1		3	3	3
3,4	1				1	
Total	14	7	5	49	26	49
Mean number	2,69± 0,14	2,86± 0,09	2,88± 0,08	2,67± 0,05	2,77± 0,07	2,67± 0,05

• "volume of the hand" in *cm*^{3}: I- up to 349 cm^3; II - from 350 to 399 cm^3; III- from 400 cm^3 and more

Table 2: Lowering of "hot" (40^{o}C) water temperature (in ^{o}C) by youths and girls of the Russian nationality.

Lowering of water tempera-ture (in ^{o}C)	*Men*			*Women*		*Total*	
	*I**	*II*	*III*	*I*	*II*	*Men*	*Women*
1							
1,2							
1,4							
1,6							
1,8							
2				1			1
2,2				1			1
2,4							
2,6	1			1		1	1
2,8		4	1		1	5	1
3	2	7	2		1	11	1
3,2	3	8	2	2		13	2
3,4		3	2	1	1	5	2
3,6	1	3	1			5	
3,8		1	1			2	
Total	7	26	9	6	3	42	9
Mean number	3,11± 0,11	3,18± 0,05	3,27± 0,11	2,78± 0,24	3,06± 0,18	3,18± 0,04	2,87± 0,17

* "volume of the hand" in *cm*^{3}: I- up to 349 cm^3; II - from 350 to 399 cm^3; III- from 400 cm^3 and more.

presented. It was done to indirectly assess the BHC through the ability of the examined individuals to increase the $t^{o}C$ of "cold" water when the $t^{o}C$ of this water is lower than the normal core temperature of a human organism.

The obtained data show that: (1) there is a wide range of variability in the studied individuals concerning their ability to increase the temperature ($t^{o}C$) of "cold" water (from 1^{o}C to 6^{o}C); (2) on average the Kyrghyz have the best ability among all to increase the $t^{o}C$ of "cold" water, and the Russians occupy intermediate position between the Kyrghyz and the Indians; (3) the male persons also demonstrated the greatest range of variability concerning their ability to increase the $t^{o}C$ of "cold" water irrespective their race-ethnical peculiarities.

In Figure 1 the dynamics of lowering the $t^{o}C$ of the "hot" water with time by Kyrghyz, Russians and Indians is shown. As is seen in these graphs, in general the Kyrghyz and Russians lower the $t^{o}C$ of "hot" water worse than the Indians. The latter lower $t^{o}C$ more intensively than the Kyrghyz, Russians, and some Indians lowered the $t^{o}C$ of water down to 36^{o}C, i.e. lower than the core temperature of the normal human body (see Table. 3).

In Figure 2 the dynamics of increasing the $t^{o}C$ of the "cold" water with time is shown. As is seen in this graph the Kyrghyz and Russians not only

Table 3: Lowering of "hot" (40 ^{o}C) water temperature (in ^{o}C) by youths and girls from India

Lowering of water tempera-ture (in ^{o}C)	*Men*			*Women*	*Total*	
	*I**	*II*	*III*	*I*	*Men*	*Women*
1						
1,2						
1,4						
1,6						
1,8						
2						
2,2						
2,4		1			1	
2,6						
2,8			1	2	1	2
3	1	4			5	
3,2	6	3	1		10	
3,4	1	3	1		5	
3,6	6	4	1		11	
3,8	3	2	1	1	6	1
4		5	1		6	
Total	17	22	6	3	45	3
Mean number	3,45± 0,06	3,46± 0,09	3,4± 0,18	3,13± 0,33	3,46± 0,05	3,13± 0,33

* "volume of the hand" in *cm*^{3}: I- up to 349 cm^3; II - from 350 to 399 cm^3; III- from 400 cm ^{3} and more

Table 4.: Increase of "cold" (15 °C) water temperature (in °C) by youths and girls of the Kyrghyz nationality.

Increase of water tempera-ture (in °C)	*Men*			*Women*	*Total*	
	*I**	*II*	*III*	*I*	*Men*	*Women*
1						
1,2						
1,4				2		2
1,6				4		4
1,8	1			2	1	2
2	2				2	
2,2	1			1	1	1
2,4		1		1	1	1
2,6	1	2	1	1	4	1
2,8		1			1	
3		1			1	
3,2		1	1		2	
3,4		1			1	
3,6	1				1	
3,8	1				1	
4		1	1		2	
4,2						
4,4		1			1	
4,6						
4,8						
5	1				1	
6		1			1	
Total	8	10	3	11	22	11
Mean	2,87±	3,44±	3,26±	1,82±	3,20±	1,82±
number	0,40	0,35	0,41	0,12	0,23	0,12

* "volume of the hand" in *cm*^{3}: I- up to 349 cm^3; II - from 350 to 399 cm^3; III- from 400 cm ^{3} and more

Table 5: Increase of "cold" (15°C) water temperature (in °C) by youths and girls of the Russian nationality.

Increase of water tempera-ture (in °C)	*Men*			*Women*	*Total*	
	*I**	*II*	*III*	*I*	*Men*	*Women*
1						
1,2	1				1	
1,4						
1,6	1			1	1	1
1,8				1		1
2						
2,2				1		1
2,4	1	1			2	
2,6						
2,8		1			1	
3	1		1		2	
3,2		1			2	
Total	4	3	1	3	9	3
Mean	2,05±	2,80±	3,0	1,87±	2,2±	1,87±
number	0,40	0,23		0,18	0,29	0,18

* "volume of the hand" in *cm*^{3}: I- up to 349 cm^3; II - from 350 to 399 cm^3; III- from 400 cm ^{3} and more

better increase the t°C of "cold" water than the Indians. They increase the t°C of water almost progressively, and only by the 20th minute they reach their "ceiling", whereas the Indians reach their "ceiling" earlier than the Kyrghyz and Russians.

Finally, from Tables 1-6 it is clear that the ability of a man to increase or lower the t°C of water also

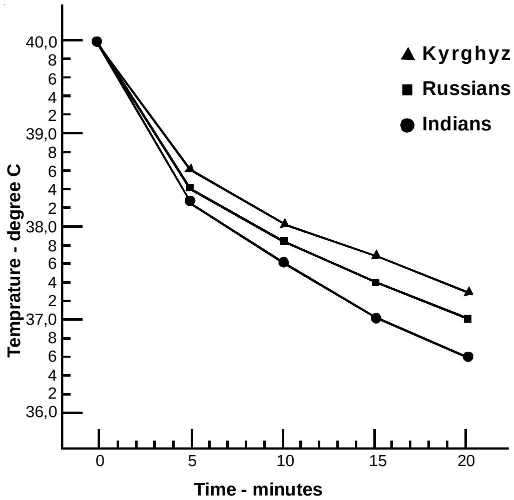


Fig. 1. The dynamics of temperature lowering (in °C) of "hot" (40.0 °C) water depending on the ethnic peculiarities of the examined individuals.

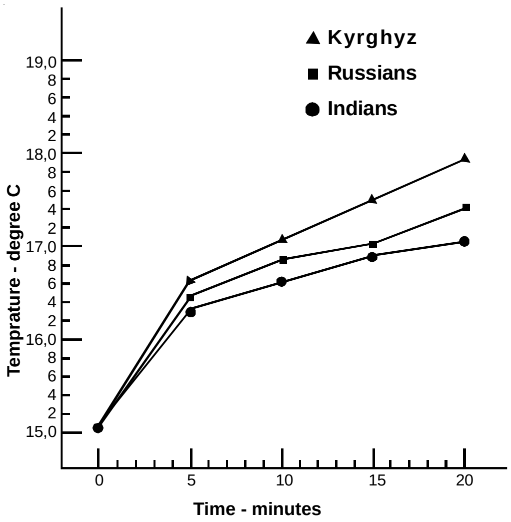


Fig. 2. The dynamics of temperature increase (in °C) of "cold" (15 °C) water depending on the ethnic peculiarities of the examined individuals.

Table 6: Increase of "cold" (15 ^{o}C) water temperature (in ^{o}C) by youths and girls from India.

Increase of water temperature (in ^{o}C)	*Men*			*Women*	*Total*	
	*I**	*II*	*III*	*I*	*Men*	*Women*
1	2			1	2	1
1,2	2	2		1	4	1
1,4	2			1	2	1
1,6	3	2			5	
1,8		1			1	
2	1	4	3	1	8	1
2,2						
2,4	2	3	1		6	
2,6	1		2		3	
2,8						
3					2	
3,2		1	1		1	
3,4		1				
3,6						
3,8						
4			1		1	
5						
5,2						
5,4		1			1	
Total	13	15	8	3	36	4
Mean number	1,65± 0,15	2,31± 0,27	2,60± 0,25	1,87± 0,18	2,13± 0,15	1,4± 0,22

* "volume of the hand" in *cm^3*: I- up to 349 cm^3; II - from 350 to 399 cm^3; III- from 400 cm ^{3} and more

depends on the VH: the more the VH the more intensive is the change of t^{o}C of water. The same relation, as one would expect, was found to be connected with the weight and height of the individuals: the more the weight and height of a person, the more it increases or lowers the t^{o}C of water (here these data are not presented).

DISCUSSION

Virtually, the life, which is known to science, is possible only at positive temperature, and its highest form – mammals – are able to keep a relatively high temperature in the body preserving a very high level of metabolism.

Temperature has a fundamental influence in all chemical and biochemical reactions. It influences reaction rates, equilibrium amounts, viscosity, solubility, molecular arrangements and numerous other parameters. Temperature is important for physiological processes as well as cell maintenance and function. The body temperature is maintained at a relatively constant level because of the balance, which exists between heat production and heat loss. If there were no heat loss even in the resting subject would produce sufficient heat to raise the body temperature by 1^0C every hour; a 69-kg man produces 70 calories of heat per hour due to the basal metabolism.

The study of the heat conductivity (HC) of physical bodies is the advanced part of physics and engineering what cannot be said concerning bodies of living organisms. The HC, from the point of view of physicists is the transfer of energy from the more heated sites of bodies to the less heated as a result of the thermal movement and interaction of microparticles. The HC results in alignment of temperature of a body.

It is obvious that any living body, including also the body of man, has some primary heat conductivity. Nevertheless, as an important physical characteristic of the living organism it did not yet attract the attention of either physicists, or biologists. It was not possible for us to find a special method in the literature, but even any attempts to estimate the BHC of the living organisms *in vivo*. It is no wonder since it turned out that even the experts on the thermoregulation never raised this issue (Blatties, 1997). Apparently, they *a priori* admit no possibility of existence of the considerable intra population variability on the BHC of man. Therefore, we were compelled by a trial and error method to develop the methodical approach for a very approximate and indirect estimation of the BHC. This method, despite its extreme simplicity gives the reproduced numerical results with which it is possible to work.

We, as physicists, in order to estimate the BHC have decided to use the capability of his organism to reduce the temperature (t^{o}C) of "hot" (40.0^{o}C) water in hope that our method would, let it be quite indirectly, still reflect the real picture. If we proceed from this precondition, the data received by us could be considered as the acknowledgement of the assumption on the probable connection between the BHC and amount of the Q-HRs in his genome at the population level (Table 7). In fact, we had showed earlier that on the amount of Q-HRs in the genome, the ethnic groups we had studied were arranged (in order of increase) in the following sequence: the Kyrgyz, Russians and Indians (Ibraimov and Mirrakhimov, 1982 b; Ibraimov et al., 1982, 1997). At the same time, as is seen from Fig.1, the Indians

Table 7. Distribution of chromosomal Q-HRs and lowering of temperature (in °C) of "hot"(40 °C) water by the Kyrghyz, Russians and Indians.

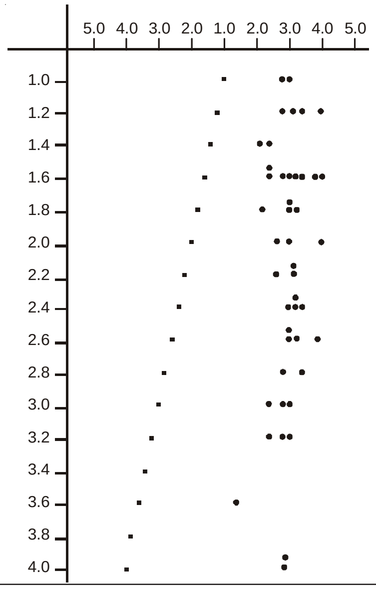
Number of Q-HRs	*Distribution of Q-HRs*			*t°C*	*Temperature of water (t°C)*		
	*Kyrghyz** *I* *(N=1122)*	*Russians*** *II* *(N=449)*	*Indians**** *III* *(N=58)*		*Kyrghyz* *I* *(N=75)*	*Russians* *II* *(N=51)*	*Indians* *III* *(N=48)*
0	94	24	1	1			
				1,2			
1	221	80	2	1,4	1		
				1,6			
2	363	141	11	1,8			
				2	4	1	
3	242	111	11	2,2	5	1	
				2,4	9		1
4	137	65	15	2,6	15	2	
				2,8	15	6	3
5	50	23	11	3	19	12	5
				3,2	6	15	10
6	13	5	3	3,4	1	7	5
				3,6		5	11
7	2		3	3,8		2	7
				4			6
8			1				
Total	2563	1100	219		202,6	159.6	165
Mean number	2,28±0,06	2,44±0,06	3,78±0,28		2,70±0,04	3,13±0,05	3,44±0,06
	$t_{I,II}$=1.88 df=1283 P<0.059	$t_{II,III}$=4.67 df=63 P<0.000	$t_{I,III}$=5.23 df=63 P<0.000		$t_{I,II}$=6.75 df=124 P<0.000	$t_{II,III}$=3.98 df=97 P<0.000	$t_{I,III}$=10.68 df=121 P<0.000

* (Ibraimov 1993); **(Ibraimov and Mirrakhimov 1982 b); *** (Ibraimov et al. 1997).

cool the "hot" water not only intensive, they do it more quickly and "more abruptly" than other two samples.

The connection we assume of between the amount of the Q-HRs and BHC is confirmed by the data analysis with taking into account the sex inside each population. From Tables 1-3 it is seen that the young men on the average cool the "hot" water better than girls. Besides, the men demonstrate the greatest range of variability. It should also be expected (Ibraimov, 2003, 2004). The point is that: a) at the level of population the amount of Q-HRs in the genome of the men on the average is greater than with the women due to the Y chromosome in their karyotype with the largest Q-heterochromatin region; b) the size of the Q-heterochromatin regions are distinguished by rather a wide quantitative variability in the population (Caspersson et al., 1970; Arrighi and Hsu, 1971; Paris Conference, 1971, 1975; Miclos and John, 1979; Verma and Dosik, 1980; Stahl and Hartung, 1981; Prokofyeva-Belgovskaya, 1986; Verma, 1988).

Table 8: Range of temperature fluctuation (in °C) when submerging a human hand in "cold" and "hot" water.



All the data given above speaks of the possible connection between the amount of Q-HRs and BHC at the population level (Table 7). Nevertheless, some data has been collected within the framework of this research, which witnesses on the possible influence of the amount of Q-HRs on the emergence of the intra population variability on the BHC. So, the data on those individuals whose abilities to change the temperature of both "cold" and "hot" water was measured is given in Table 8. On the left-hand side of the Table the figures showing the t^{o}C of cold water after the hand of the person are given. On the right-hand side of the Table in the form of dots (from left to right, in order of increase) the figures showing the temperature of the water with the same individuals 20 minutes later after they had submerged their hands into the flask with the "hot" water are located.

In contrast to our expectation, we saw no individual who would be able to heat up "cold" water as well as he would cool well the "hot" water, and vice versa. Nor it was revealed that the individual who is badly heating up "cold" water should cool "hot" water well, and vice versa. It is seen from Tables 8 and 9 that: a) the strict limit in the range of temperature fluctuations of water "towards both sides" and the limit of the temperature variability in sum constitutes merely about 5.5^{o}C (Table 9); b) evidently, each person has an individual point "stop" within this narrow temperature range. Thus, for instance, if this individual has heated the "cold" water by 3.5 ^{o}C, then he would cool the "hot" water not more than by 1.5^{o}C, so that the sum of these two figures would not exceed 5.5^{o}C (Table 9).

In this way, we have received the picture, which is not completely in compliance with the laws of the thermophysics when the body conducts the flow of the thermal energy towards both sides equally. So far we do not know

Table 9: Range of temperature fluctuation (in ^{o}C) when submerging a human hand in "cold" (15 ^{o}C) and "hot"(40 ^{o}C) water

	Kyrghyz		*Russians*		*Indians*	
t^{î}Ñ	*"cold" water I (N=32)*	*"hot" water II (N=75)*	*"cold" water III (N=12)*	*"hot" water IV (N=51)*	*"cold" water V (N=40)*	*"hot" water VI (N=48)*
1					3	
1,2			1		5	
1,4	2	1			3	
1,6	4		2		5	
1,8	3		1		1	
2	2	4		1	9	
2,2	2	5	1	1		
2,4	2	9	2		6	1
2,6	5	15		2	3	
2,8	1	15	1	6		3
3	1	19	2	12		5
3,2	2	6	2	15	2	10
3,4	1	1		7	1	5
3,6	1			5		11
3,8	3			2		7
4	1					6
4,2						
4,4						
4,6						
4,8						
5	1				1	
6	1					
Total	86.4	202,6	28,4	159,6	82,4	165
Mean number	2,70±0,19	2,70±0,04	2,37±0,19	3,13±0,05	2,06±0,13	3,44±0,06
Sum	5,40		5,50		5,50	

completely the physical mechanism and biological sense of this phenomenon. However, one circumstance seems to be quite certain; the sum of range of fluctuations of the t^{o}C (~5,5^{o}C), also received in our experiments at the population level (Table 9) is suspiciously close to the figure which is well known from the physiology of man. Namely, ~5,5^{o}C, this limit of the temperature variations in organism – between 35.5 and 41.0^{o}C –, which is still compatible with the life of man and is dependent on the organ-based physiological thermoregu-lation.

Naturally, simultaneously the question arises: what can be laid down into the basis of the so wide intra population variability and considerable inter population differences on the BHC. Apparently, it is difficult to explain these distinctions by the racial-ethnic or sex features in the physiology of the thermoregulation. It had been established long ago that not only the representatives of the *H. sapiens* but all the mammals as well do not essentially differ on all the major mechanisms of the organ-based physiological thermoregulation, at least, in a state of rest and in the conditions of temperature comfort, that is, in the conditions similar to our experiments. Therefore, the effect of the amount of Q-HRs in the CC composition through the cell thermoregulation on the BHC (Ibraimov, 2003) seems to be more probable.

But how can it happen? Of all the emerging issues the most complicated one is the following: Why a man with the high BHC cools "hot" water well but cannot heat up "cold" water at least by the same t^{o}C?

From the point of view of physics, the capability of the man with the high BHC to lower the t^{o}C of "hot" water (40.0^{o}C) is quite an understandable phenomenon since in this case the flow of the thermal energy of man is directed from the environment towards the body. It is more complicated to imagine why the same person cannot raise the t^{o}C of "cold" (15.0^{o}C) water, that is, why the heat runs badly from such body towards the environment with the availability of the essential temperature difference between them? The possible cause, in our opinion, is not in breaking the laws of the thermodynamics but in the peculiarities of structure of the human body and his capability to support the relatively constant temperature inside the organism within very narrow limits. The body of man is not a homogeneous physical mass. The organism of man permanently and very actively responds to the temperature variations inside the body and outside it. But the most essential thing; the BHC, as we believe, consists of, at least, the two major components: the transfer of the thermal energy for short and long distances. The first component – the physical – is apparently limited by the separate cells where the heat is transferred between the cytoplasm and nucleus inside the cell or between the neighboring cells in the tissue. The second component – the physiological – is the transfer of the heat for long distances; from the hotter sites of the body towards the less hotter with the help of the fluids such as blood and lymph which circulate across the whole organism.

Now let's get back to the situation when the hand of the man with the high BHC is in the "cold" water. The skin thermoreceptors immediately send the corresponding signals to the center (hypothalamus). In response the mechanism of the physiological thermoregu-lation is switched on and this reaction is essentially the same for all individuals, including those independently from the difference of the heat conductivity of their bodies. The distinctions in the final results are, apparently, connected with the physical component in the BHC. In the above case the hand itself cools quickly due to its high heat conductivity, that is, it quickly gives away the major part of its own internal heat to "cold" water, which is witnessed by the characteristic dynamics of reducing the t^{o}C of "cold" water, for example with the Indians (see Fig.1). And a small rise of temperature is provided as a result of the high inflow of blood, that is, at the expense of the physiological component of the thermoregulation.

And what may happen with the individual with the low BHC who badly cools the "hot" but heats up "cold" water well? Probably, in case with "hot" water the flow of heat from the environment towards the body is made much difficult due to the low BHC, that is, the hand, to a certain degree, protects the body from the small local temperature disturbance. The part of the heat that has gone into the body through the hand is taken away by the well-known mechanisms of the physiological thermoregulation. The cause of the good heating of the "cold" water is as follows: a) the current of the thermal energy from the body into the environment is considerably slowed down so that the hand only partially loses its own internal heat; b) the losses of the heat of the hand at the expense of the physical component of the heat conductivity is compensated by the intensified inflow of blood, that is, by the physiological component of the thermoregulation due to which the temperature of the water raises. As we believe, the same principle of the thermal exchange takes place in all the other cases when the difference of the temperature between the body of man and the environment takes place.

For the time being little is known about other mechanisms of thermoregulation, including the molecular and cellular ones, through which the amount of Q-HRs in genome could influence the BHC of a man (Ibraimov, 2003, 2004). However, by today quite a lot of other data on different effects of Q-HRs in human populations have been accumulated. Also there are a number of other medical-biological observations, which, as we assume, will help at least intuitively catch the relation we are looking for. Some examples are given below.

1. Our physiological experiments have been carried out on individuals of the same age group. Therefore it is impossible to discuss a possible influence of age and amount of Q-HRs on BHC of a person on the basis of these data. Nevertheless, in this respect there are the results, which deserve attention.

The first example of the possible effect of chromosomal Q-HRs is features of their quantitative distribution in individuals belonging to different age groups in the population. In particular, it was shown that chromosomal Q-HRs are most numerous in the genome of neonates, while they are least numerous in the genome of elderly subjects (aged 60 years and older) regardless of the ethnic features of the individuals studied (Buckton et al., 1976; Ibraimov and Karagulova, 2006).

As our data show, among neonates the number of Q-HRs in the karyotype ranges from 0 to 7, while the mean number of Q-HRs per individual ($\overline{x}$) amounted to 3.16 ± 0.13 in Kyrghyz neonates and 3.59 ± 0.23 in Russians. In elderly Kyrghyz subjects the number of Q-HRs in their karyotype ranged from 0 to 4, with $\overline{x}$ equal to 1.91± 0.02, while in Russians – from 0 to 6, with $\overline{x}$ = 1.88 ± 0.08 (Ibraimov and Karagulova, 2006). Unfortunately, Buckton et al. (1976) who were the first to detect age related differences in the mean number of Q-HRs, give no data on the distribution of Q-HRs per individual in a population. Nevertheless, from $\overline{x}$ values we can guess that they obtained data on the distribution of numbers of chromosomal Q-HRs that were similar to ours.

There is no agreement as to the nature of such Q-HRs variability. It is possible that a decrease in the number of Q-HRs with age in a population is not an ontogenetic process, but rather the results of natural selection where individuals with a greater amount of chromosomal Q-HRs in their genome than on the average in a population "fall out" (Ibraimov and Karagulova, 2006). However, when we are speaking of concrete mechanisms, i.e., which properties of Q-HRs had a negative effect on survival of infants, we can but resort to speculative reasoning.

The attempt was made to justify view about possible participation of condensed chromatin (CC) in cell thermoregulation on the basis of own original researches on variability of chromosomal Q-heterochromatin regions in human populations, as well as analysis of existing literary data on CC in an interphase nucleus in higher eukaryotes. CC, being the densest domains in a cell apparently conducts heat between a nucleus and cytoplasm when there is a difference in temperature between them. Heat conductivity effect of CC is stipulated by its principal features: consists mainly of short non-coding DNA sequences, condensed state during the interphase, replication at the end of the S period of a cell cycle, association with the lamina and the inner nuclear membrane, formation of chromocenter, genetic inertness, wide interspecific and intraspecific variability on the quantitative contents (Ibraimov, 2003, 2004).

Thus, how do we explain age-related differences in the genome of neonates and elderly subjects? For the sake of convenience let us divide individuals in a population into two extreme groups: with a large and lesser amount of Q-HRs in the karyotype, respectively with high and low heat conductivity of cells, in the long run, of the entire body (Ibraimov, 1993, 2002a, 2004) and consider all this using as an example neonates and subjects aged 60 and over (Buckton et al., 1976; Ibraimov and Karagulova, 2006).

We suppose that infants with a great amount of Q-HRs in their genome are possibly subject more frequently to over cooling, catarrhal disease, etc. due to high heat conductivity of their body. Whereas, individuals with a low heat conductivity of body possibly have a certain advantage as concerns their survival in infantile age as compared with those who have a medium and especially great amount of chromosomal Q-HRs in genome. That is how we explain the "redundancy" of individuals with a lesser amount of chromosomal Q-HRs in genome in the population of elderly subjects (Ibraimov and Karagulova, 2006).

By the way, we continue our observations of children in whom we studied the amount of Q-HRs in umbilical blood cultures (Ibraimov and Karagulova, 2006). 22 neonates have deceased from various diseases in hospitals during this time, and from them 17 Kyrghyz and 5 Russian ones, the diagnosis of which is confirmed by pathological-anatomical dissection. Here it is necessary especially note that we unfortunately have not observed for a destiny of all neonates investigated by us, as the transit economics which is in post-soviet Kyrghyzstan, compels a large part of the population to change permanently a place of residence in searches of job and often far outside the country. But nevertheless even this small actual material, as we believe, can present an interest.

In Table 10 the distribution and mean number of Q-HRs ($\bar{x}$) on autosomes in neonates (Ibraimov and Karagulova, 2006) is shown and in individuals died. As can be seen from this Table, neonates are characterized by a high range of variability in the distribution of Q-HRs (from 0 up to 7). But died neonates, besides high value $\bar{x}$ differs by extremely narrow range of variability of Q-HRs in population: number of Q-HRs in a karyotype changes from 4 up to 6, with $\bar{x} = 4.58 \pm 0.23$ and $\bar{x} = 4.80 \pm 0.37$ in Kyrghyz and Russian respectively. For all that it turned out that the overwhelming majority of deceased infants were of male sex.

As early as 70-th years of XX century chromosomal Q-polymorphism was investigated by one or another reasons in hundreds and thousand of neonates in the world (Müller et al., 1975; Buckton et al., 1976; Lin et al., 1976), destiny of which can be observed at present time, though in developed countries. We are going continue our observations. In this connection it would be helpful if the authors studying the amount of Q-HRs in neonates did the same, for facts obtained under different ethnic, climatic, and socioeconomic conditions will be exceptional importance if the different amount of Q-HRs in the genome of individuals in different age groups (Buckton et al., 1976; Ibraimov and Karagulova, 2006), is not really fortuitous.

Indirectly other known medical-biological data justify our point of view:

1) the level of infant mortality and morbidity

Table 10: Distribution and mean number of Q-HRs per individual in neonates* and infants died.

Number of Q-HRs	*Kyrghyz Neonates I (N = 145)*	*Infants died II (N = 17)*	*Russians Neonates III (N = 37)*	*Infants died IV (N = 5)*
0	4			
1	19		3	
2	23		7	
3	38		5	
4	37	9	12	2
5	16	5	7	2
6	5	3	3	1
7	3			
Total number of Q-HRs	458	79	133	24
	$\chi^2_{I,II}=9.03$ df=2 $P<0.05$	$\chi^2_{I,III}=2.18$ df=2 $P>0.05$	$\chi^2_{I,IV}=6.18$ df=2 $P<0.05$	
	$\chi^2_{II,III}=2.23$ df=2 $P>0.05$	$\chi^2_{II,IV}=0.28$ df=2 $P>0.05$	$\chi^2_{III,IV}=2.26$ df=2 $P>0.05$	
Mean number of Q-HRs	3.16 ± 0.13	4.65 ± 0.19	3.59 ± 0.23	4.80 ± 0.37
	$t_{I,II}=6.47$ df=36 $P<0.000$	$t_{I,III}=1.52$ df=180 $P> 0.100$	$t_{I,IV}=2.33$ df=148 $P<0.021$	
	$t_{II,III}=3.55$ df=52 $P>0.001$	$t_{II,IV}=0.37$ df=20 $P> 0.500$	$t_{III,IV}=1.88$ df=40 $P>0.050$	

* Ibraimov and Karagulova, 2006.

is higher with boys than girls. This trend especially expressed in high mountain climate conditions (Baker, 1978);

2) apparently, girls are better than boys "protected" from hunger and diseases, and the trend of curve of their physical growth breaks very rarely (Harrison et al., 1977);
3) mortality from infectious diseases in males is, on average, two times higher than in females;
4) in all ethnic groups males almost 2 times more often are sick with tuberculosis (TBS) than females. For example, in the USA the Afro-Americans are more susceptible to TBS that determines quick progress of the disease. Vice versa, in "whites" the TBS more often acquires chronic than acute form;
5) also it is known that among the animals only apes get our common cold and stand it very badly.

Aside from effects of hypothetical sex-chromosome factors, the increased disease stress in males is poorly understood (Green, 1992; Synnes et al., 1994). The increased susceptibility of males to nutritional insult in early life, reported in both human and other animals (Katz, 1980; Smart, 1977, 1986; Lucas et al., 1990, 1998), is also generally assumed to be an unresolved biological issue (Lucas et al., 1998). Both morbidity and mortality are consistently reported to be higher in males than in females in early life, but no explanation for these findings has been offered. The latest attempt to explain this phenomenon belongs to Wells (2000), who argues that "the sex difference in early vulnerability can be attributed to the natural selection of optimal maternal strategies for maximizing lifetime reproductive success" and "that whatever improvements are made in medical care, any environmental stress will always affect males more severely than females in early life."

High morbidity and mortality in infants could be explained, in addition to the known to present day medicine reasons, by a simple physical consideration. As is known, in young children the surface/volume is very high, than that in adults. When one more physical factor, such as high BHC is added, than male neonates, which genome contains more Q-HRs than in girls, become very vulnerable to the factors violating the temperature homeostasis in their immature organism, particularly to common cold and its complications with all subsequent consequences.

In any case in search for the reasons of the above phenomenon, one hardly can ignore the facts of Q-HRs presence in the genomes of gorilla and chimpanzee (Seuanez, 1976; Pearson, 1973, 1977), high Q-HRs content in the genome of the sub-equatorial Africa residents (Ibraimov and Mirrakhimov, 1982 c) and tropical zones of India (Ibraimov et al., 1997) than in the genome of populations from the moderate Euro-Asia zones, as well as availability of the largest Q-heterochromatin region on Y chromosome in male karyotype (Paris Conference 1971, 1975).

2. Alcoholism and drug addiction are a purely human pathology. Despite the obviousness of ethiology, the pathogenesis of the development of these diseases is still unclear, although there never was a lack of hypotheses and theories. Therefore, not aspiring to originality, we suppose that the role of chromosomal Q-HRs in the genome cannot be fully denied. As we have shown, in the genome of patients abusing strong alcoholic beverages the amount of Q-HRs is very small; while in drug addicts it is on the contrary great (Ibraimov et al., 2002). The possible role of BHC in these situations seem to us to be as follows: frequency of taking strong alcoholic drinks has a trend for increase by latitudes (from South to North), and by altitude above sea level, whereas the amount of Q-HRs in genome has a trend to decrease as the geographical latitude and altitude of permanent residence of human population increase (Ibraimov and Mirrakhimov, 1985; Ibraimov, 1993, 2003). Let's conceive the utmost example. In a sense, living in the Far North or in the high mountains, sometimes, predispose to taking strong drinks just for having thermal comfort. However, given this, we assume that one and the same dose of alcohol taken by persons with different BHC may result in different consequences. So, in the individual with low BHC the alcoholic intoxication begins after he takes a relatively large amount of alcohol for one drink because of lower leveling of temperature in different parts of body that finally leads to stronger intoxication with a hang-over syndrome than with persons with normal or high BHC. In other words, the lower BHC of an individual, the slower the intoxication begins. It is due to the lower time needed for heating the whole body that is necessary for having a sense of thermal comfort in the whole organism.

With drug addicts, i.e. the individuals with high BHC (because of high amount of Q-HRs in genome), drug addiction also appears due to the desire to have a sense of thermal comfort as soon as possible, but this time this "pleasure" is a result of a "drug overcooling" of the body that have subsequent emotional, or other experiences. We believe that the psycho-emotional effects of alcohol and drugs on the organism are attributed to the degree of violation of the temperature homeostasis, but they are manifested in quite opposite directions. In other words, while ethanol causes alcohol intoxication increasing the body heat (oxidation of 1 gram of ethanol produces 7 kilocalories), drugs, on the contrary, lower the temperature, thus causing the state of drug stupor.

Within our hypothesis it would be partially possible to explain the specificity of alcoholism of females as well. As Jones and Jones argue (1977) "females comprise approximately the same number of social drinkers as males in our society… It appears possible that the effects of alcohol might be different for females than for males. We have found that females obtain significantly higher peak blood alcohol levels than males on the same alcohol dose, calculated on total body weight. We also found differences in males and females in absorption and elimination rates". The point is that on average the total amount of Q-HRs in female genome is almost as twice as less than in the male genome, as in the karyotype of the latter ones there is a Y chromosome with the largest human Q-heterochromatin region (Paris Conference, 1971, 1975). It is possible that for this reason the females have quicker addiction, and it is more difficult to cure them, as it is known that the characteristic feature of female alcoholism is its great malignancy, quicker progress accompanied by faster formation of physical dependence.

Natural strive of a person to get pleasure out of "deep coolness" in conditions of hot climate, or thermal comfort in the North or high mountain conditions would be a quite justified wish, in case it is not satisfied through the drug stupor or alcohol intoxication. Nevertheless, the notorious susceptibility of the southerners to drugs, and northerners and highlanders to strong alcohol beverages may be explained, to a certain degree, by different Q-HRs content in their genome (Labs et al., 1977; Ibraimov and Mirrakhimov, 1982 b, c; Ibraimov et al., 1990, 1991, 1997), and accordingly relate it with the human BHC.

3. Let us now consider the situation with obesity. As we have shown, individuals with lesser amount of Q-HRs in genome are more prone to develop alimentary obesity (Ibraimov and Karagulova, 2002). The results of numerous epidemiological researches, which were carried out in many countries and regions have unambiguously shown that females suffer from obesity two times more often than males. We assume that alimentary obesity is not the result of lack of inner discipline in taking meals or presence of hypothetical "gene of obesity". In individuals with low BHC that is characteristic for the female organism in general (see Table 1), even if they take normal amount of food, fat will be stored in more amount than in persons with high BHC. It is easy to imagine that these individuals with a good heat isolating body, when they consume food rich in calories that is easily assimilated and who are under conditions of contemporary comfortable life possibly become more vulnerable to develop alimentary obesity (Ibraimov and Karagulova, 2002).

4. It is known that with age the number of women in a population begins to prevail over men. Such a change in the sex ratio is usually explained by the fact that men are more subject to the effects of harmful factors (smoking, alcohol, etc.) or are more frequently engaged in professional activity with increased risk for life. Without calling in question the opinion of most people we suppose that a change in the sex ratio with age in favor of women is related to the amount of Q-HRs in their genome (Paris Conference, 1971, 1975). It is possible that a certain advantage of women is explained by their relative resistance, as compared with men, to cold and stress, hunger and even loss of blood because they have less heat conductivity body (Ibraimov, 2002 a, 2004). In order to be convinced of the relative resistance of women to cold and stress, we shall given several known examples: a) pearl-divers in Korea are exclusively women – "ama" (Folk, 1974); b) women succeed best in swimming across the cold water of La-Manche (Folk, 1974); c) during the period of the Leningrad blockade during the World War II about 80% of the women survived despite the fact that being in the rear they had a lesser access to food; d) at the reproductive age women, without detriment to their health lose every month from 120 to 300 ml of blood during menses and about 300-500 ml of blood even during normal labor. Men could hardly

tolerate these losses of blood without detriment to their health. Thus, the known thesis that males seem to be less resistant to environment stress is also somewhat explained from our point of view.

In this connection another observation deserves to be remembered. Hertig and Sargent (1963) demonstrated that women like men can be artificially acclimated to heat and they manifested the same physiological adjustments: reduced pulse rate, reduction in core temperature, rise in skin temperature, and onset of sweating at a lower skin temperature, lessened discomfort, and increased sweat rate. The females studied have relatively quickly reached the limits of endurance in the hot environment selected. Males easily tolerated this environment. The authors suggest that two factors appear to be operating to put the female at a disadvantage in the heat: (a) lower thermal gradient for removal of metabolic heat; (b) less reserve capacity to move blood to the skin (Hertig and Sargent, 1963). Besides, the women had less sweating by about 50% than men (Folk, 1974). Not contesting the explanations of physiologists, we would add here the supposed by us possible heat conductive effect of chromosomal Q-HRs on temperature homeostasis (Ibraimov, 2004), believing that manifestation of heat losses should be smaller in women.

5. Comparative tests for endurance of the “whites” and “blacks” to physical load in conditions of heat and high humidity demonstrate superiority of Negroes even over those “whites” who are used to working in such conditions. On the other hand, the experience of war in Korea showed that frostbite occurs much more often with Negro soldiers than with the “whites” (Folk, 1974). Long-term experience of the Indian medical officers in the Himalayas shows that the South Indians are physiologically more susceptible as compared to Gorkhas and North Indians under identical environmental conditions and that the high altitude population is more resistant to cold injures. It was shown that South Indians are more susceptible to frostbite than other ethnic groups of this country (Mathew, 1992);

6. It remains to cite other observations made in world of sport that, as we suppose, deserve attention. In recent years more and more developing countries in southern latitudes are taking part in the world sportive movement. This made us pay attention to the following aspects: individuals of the southern continent began to achieve remarkable successes in sports requiring, in addition to other things, effective heat losses in the organism. That is football, professional boxing and Marathon races. At the same time, athletes of northern countries dominate in aquatic and winter sports, as well as in mountaineering (Ibraimov et al., 1990, 1991). As we understand, these phenomena could be explained by the fact that prevalence of individuals with a large amount of chromosomal Q-HRs in their genome is characteristic of native residents of tropical and subequatorial zones (Lubs, 1977; Ibraimov and Mirrakhimov, 1982 c; Ibraimov et al., 1991). Therefore their bodies with relatively high heat conductivity promote more successful sport employment that in addition to the things require effective heat losses in the body (Ibraimov, 2004). Really, by the curve of decreasing of the “hot” water temperature (see Fig. 1) it is easy to make sure that the Indians very quickly and intensively cool water. If to extrapolate this situation in general on the bodies of the native residents of the tropical zones (Ibraimov, 2003; 2004), it is possible to conclude that the bodies of native southerners possessing high BHC are inclined to quick supercooling in cold water, and this circumstance can be a serious obstacle in achieving high athletic results by them, as, for example in swimming across the La Mansh.

7. Many people wrote about the possible role of chromosomal heterochromatin regions in the adaptation of plants and animals; although all of them had in mind either C-heterochromatin or some classes of highly repetitive DNA in the genome. This is most convincingly demonstrated in plant evolution and DNA content. Thus, most annual plants have less nuclear DNA than perennial plants (Bennett, 1972). There is also a positive correlation between DNA content and minimum duration of the mitotic cycle (Evans, 1972). Nagl (1974) found that the amount of C-HR per genome is related to the reduction of cell cycle time in annual plants with large DNA contents. He concluded that the amount of C-HR is an important factor in determining both nuclear DNA content and growth rate parameters (Nagl, 1974). In general, DNA amount tends to increase with increasing heterochromatic knob number, and to decrease with increasing latitude or altitude of cultivation (Rayburn and Auger, 1999). Summarizing all these studies Bennett (1998) came to the conclusion that “…DNA amount correlates

closely with many important phenotypic characters, and many of the relationships between DNA amount and various cellular characters are strikingly precise for biological phenomena and more reminiscent of physical relationship."

Comparison of the contents of the satDNA in 12 species and subspecies of the genus *Dipodomys* (kangaroo rats) with their ecological and biological features have shown, that the amount of the satDNA is directly connected to a degree lability of species, speed of its adaptation to unexpected changes of an environment conditions, and consequently the species with richness satDNA have many subspecies. On the contrary, narrow specialized species, which occupying limited niches, have poor quantity of satDNA and have a few subspecies (Mazrimas and Hatch, 1972).

We have obtained the first data on possible role of the amount of chromosomal Q-HRs in the adaptation of man to certain extreme climatic-geographical conditions of Eurasia in the early eighteens (Ibraimov and Mirrakhimov, 1982 a, b, c; Ibraimov et al., 1982). Lately these observations we replenished by new data (Ibraimov 1993; Ibraimov et al. 1990, 1991, 1997). In particular, it turned out that:

a) the amount of Q-HRs is considerably lower in the genome of populations living permanently at northern latitudes and high-altitude regions, than in populations living in temperate zones of Eurasia and subequatorial Africa (Ibraimov and Mirrakhimov, 1982 a, b, c, 1985; Ibraimov et al., 1982, 1986; Ibraimov, 2003);

b) low amount of Q-HRs is a characteristic feature for genomes of mountaineers (Ibraimov et al., 1990) and alien oil industry workers who are well adapted to the climate of the Extreme North of Siberia, and mostly are busy with the open-air physical labor (Ibraimov et al., 1991);

The most important environmental factor in the adaptation of our remote ancestors to temperate and northern latitude was apparently temperature of the surrounding environment, especially cold. Certain physiological and biochemical changes in the acclimatization of the human organism to cold are known. However, many people continue to assert the existence of some genetic mechanisms of human adaptation, in particular to hypoxia (Little and Garruto, 2000; Beall, 2000), but numerous attempts to find conjectural structural genes or gene complexes of adaptation in the human genome were not successful as yet (Ibraimov and Mirrakhimov, 2002).

Nevertheless, the rapid (on an evolutionary scale) and effective mastering of all the oykumene by man is indeed a unique phenomenon, and this makes one ponder over the fact that here possibly were involved not structural genes but some mobile, non-conservative part of the genome. Thus, our data suggest that for adaptation to cold *H. sapiens* apparently used the Q-heterochromatin part of his genome (Ibraimov et al., 1982, 1986, 1990, 1991, 1997; Ibraimov and Mirrakhimov, 1982 a, b, c, 1985, 2002). However, we can hardly imagine as yet how this genetically inert material could be used in the adaptation of man to cold. Therefore, in order to relate in some way the possible mechanism of the influence of chromosomal Q-HRs to man's vital activity, including his existence under conditions of cold and hot climate, we were compelled to admit first of all that Q-HRs in composition of CC have some heat conductive effect in cell (Ibraimov, 2003, 2004). We suppose, that *H. sapiens*, besides those inherent in all mammals possesses an additional but very fine and simple mechanism of thermoregulation. In the present case, in order to preserve temperature homeostasis under different environmental conditions, in addition to physiological, behavioural and biochemical mechanisms such as wide intra population variability by BHC was used (Ibraimov, 1993, 2002 a, 2003). Possibly, for the *H. sapiens* BHC diversity is necessary because no single genotype can possess a superior adaptadness in all environments.

It generally considered that the *H. sapiens* is characterized by the highest physiological plasticity, though there are no concrete data to justify availability in a man a special physiological mechanism of thermoregulation, which differs from other mammals. Of course, the mind of a man is the best creation of evolution. However for existence in conditions of high altitude hypoxia even the modern human cannot oppose anything essential, invented by his high intelligence. Nevertheless, only very few doubt that a man possesses the highest physiological plasticity. Apparently, most likely, when speaking about this phenomenon the fact of inhabiting very different climatic-geographical provinces by man is meant. But we assert that the basis of high physiological plasticity of *H. sapiens*, is possibly a wide quantitative variability of chromosomal Q-HRs in population, which through the change of the CC physical density in a cell exert modifying influence upon the level of heat conductivity of the whole human body.

Evidently, in reality one and the same person does not possess equally good adaptation to heat, cold and high altitude hypoxia. However, in any human population there are individuals able to efficient adaptation either to tropical climate, Extreme North, or high altitude conditions. Only in this sense it should be understood that a man as a biological species, but not as an individual, can adapt to heat, cold or high mountain hypoxia. And as we assume, it is possible that in the basis of such high physiological plasticity of *H. sapiens*, in addition, there is a wide variability of his BHC in population. Really, selection affects not an individual, but the local population (Mayr, 1970).

Thus we believe that: (1) human bodies in population significantly differ from each other, in addition, by heat conductivity; (2) heat conductivity of cellular part of a body depends on the CC density, in formation of which in a man the amount of Q-HRs in his genome plays an important role; (3) organ-based physiological thermoregulation in a man is realized in different physical conditions in form of different BHC.

Origin and Evolution of the Body Heat Conductivity

Thermoregulation is the physiological property of the organism, which serves for maintaining constant internal temperature environment at the level established by hypothalamus through keeping balance between the heat production and heat loss. The heat conductivity as the physical property of the body balances the temperature in its various parts, as we believe, an important element in the system of the thermoregulation with living organisms. Both the thermoregulating and heat conductive properties of the living organisms, obviously, emerged in the process of their adaptive evolution to the constantly changing temperature conditions of the environment (Ibraimov, 2003, 2004).

Though the demonstration of the existence of the intra population variability on the BHC of man in principle turned out to be not complicated, the question arises: Is man the only possessor of this variability or is it inherent to the other large multi-cellular animals too? Since the intra population variability on the BHC of man, obviously, is the result of the evolution of the chromosomes and, namely, of its heterochromatin part (Ibraimov, 2003, 2004), then, even having no corresponding experimental data it is possible to expect that such a phenomenon may be inherent to the other higher eukaryotes if in their genome the quantitative and qualitative variability of the constitutive heterochromatin exists. Under such a view on the nature of variability on the BHC the eternal question in biology arises: when and why did it emerge?

It is obvious that the transfer of the thermal energy for short distances becomes possible with the emergence of the eukaryotic cells and this question have already been discussed in detail in connection with the cell thermoregulation (Ibraimov, 2003, 2004).

Let’s try to comprehend when and why the long distance transfer of the thermal energy (LDTTE) could emerge. It is not difficult to imagine that the necessity in the LDTTE became possible with the emergence of the large multi-cellular animals with sufficiently high level of metabolism when in the process of the life activity in different parts of the body sections with different temperature started to appear. It is natural that under such conditions the organism will strive, in some way, to balance the differences in temperature in the body and, apparently, in the final end the natural selection had preserved precisely the circulatory systems (CS) as means of the far distance transfer of heat. Yet such a system of the thermoregulation emerged only in the Trias about 225 million years ago while the large multi-cellular animals still existed in the Cambrian more than 570 million years ago.

The following three components should be included in the composition of any CS: 1) the circulatory fluid which is usually blood; 2) the retractable organ which functions like a pump and provides for the running the fluid through the whole body (the heart or modified blood vessel); 3) the tubes inside which the fluid circulates (usually blood). Since on the origin of the CS in the process of the evolution there are no special researches we have no choice other than to speculate on the basis of the data on the fluid circulation in the body of the presently living animals in order to have the most probable picture.

So, the Protozoa have no special system for implementing the circulation of substances; the nutritive materials, products of metabolism and respiratory gases - they simply diffuse through the cytoplasm and in the final end reach all the parts of the cell (through the movement of the cytoplasm).

The central cavity implements the transport and digestion function in the Coelenterata. As a result of the alternate outstretching and contraction of the body the contents of the central cavity gets intermingles and the circulation of substances takes place.

The hydra has, in addition to the internal and external layers, the third one, a loose layer of the cells that is located between two others. The spaces between these cells is filled with the intercellular (tissue) fluid, which to some extent resembles the human tissue to where the nutrients diffuse through the internal layer of the cells from the central cavity. Similar procedure occurs in relation to the Coelenterata, the circulation is maintained by the contractions of the muscles of the walls of the body, which set in motion the fluid contents of the central cavity and tissue fluid.

The earthworms and forms of the animals close to them have the well-defined CS consisting of the plasma, blood cells and vessels, though the latter haven't yet been identified as the arteries, veins, and capillaries. There are 5 pairs of "hearts" in the front part of the body – small pulsating tubes, which drive the blood from the spine vessel of the abdominal cavity and which encloses the system of the blood circulation. The contractions of the muscles of the wall of the body help these "hearts" to maintain the blood circulation in the body.

All the comparatively large invertebrates (the bivalve mollusks, squids, crabs, insects) have the blood CS consisting of a heart, blood vessels, plasma and blood cells.

The CS system of all the vertebrates is mainly constructed in a similar way. All these animals have both a heart and aorta, as well as arteries, veins and capillaries. In the course of the evolution from the lowest fish-shaped forms of the vertebrates up to man the major changes took place in the heart and were associated with the respiratory mechanism – with the transformation from the gills breathing to the lungs breathing. In the course of the evolution of the vertebrates the separation of the right and left halves of the heart took place, as a result of which the blood of the mammals and birds contains more oxygen which allowed them to maintain the high intensity of metabolism and constant temperature of body with all the consequences proceeding from that (relatively lesser dependency on the temperature variations of the environment, freedom of movement on land, temperature homeostasis inside the body and many other things).

From the above mentioned it may seem evident that the CS had emerged in response to the requirement of the organism of the multi-cellular animals in the transfer of the nutrients and gas exchange through the whole body, that is, the answer might seem to suggest itself. Yet since nothing has a purpose in Nature, then it seems to be reasonable to seek the answer to the question asked above not in satisfying "the purpose" but in the inevitability of the CS as the consequence of the natural processes which took place in the organisms of some species of the multi-cellular animals. Probably, such situation initially quite resembled the one which is observed in case with the hydra which in addition to the two (internal and external) layers of cells, has a third loose layer of the cells located between the two others in which there are spaces between cells filled with the tissue fluid. This fluid similarly to that of the Coelenterata circulates throughout the whole organism thanks to the contraction of the muscles of the body walls. Giving these examples, we in no way ascertain that the CS have emerged in the evolution for the first time exactly with the hydra and organisms similar to them or the circulation of the tissue fluid in the body was the expedient process in satisfying the still growing demand for the Metazoa in the best distribution of the nutrients in their organisms. Vice versa, we believe that the initial cause in the origin of the CS was as follows:

1) the simple physical processes such as the emergence of some macroscopic Metazoa of the permanent part with the various temperatures in the processes of their vital activity;

2) existence of the intercellular spaces filled with the tissue fluid which re-flow from one part of the body into the other with the availability in the organism of the parts of various temperatures or pressures. As is well known, in the

condensed medium (fluid and solids) the pressure has the "thermal" constituent associated with the thermal oscillation of the atoms (nuclei) as well;

3) availability of the contractive muscle cells in the body walls both with the Coelenterate, hydra and animals similar to them.;

The fact that the CS has initially emerged not for the transfer of O_2 and CO_2 across the whole of the organism is confirmed by such examples as:

a) the gas exchange with the Arthropod is carried out through the system of the tracheas, that's why their CS are not used for transfer of the respiratory gases. Their blood (hemolymph) is colorless and it contains no hemoglobin (Hb);

b) the Annelida, owing to the availability of the coelom of the body wall, are separated from the internal organs which provides the independence of the movement of such formations as the intestine. In this way, in the Annelida the CS implements the connection between the digestive tube and the body walls, that is, it does not serve for the transfer of the respiratory gases;

c) in closed CS (with the Echinodermata, Chephalopoda, Annelida, vertebrates) along the whole way the blood is put into special vessels which does not come into the direct contact with the cells of the tissue. The entrance to this closed loop system and exit from it is implemented only through the intercellular fluid. An animal with a closed CS has a third fluid, blood, in addition to its intra- and extracellular fluids. Materials in the blood diffuse first through the capillary walls into the extracellular fluid, and from there, they may diffuse into the interiors of cells. For instance, an adult person has about 10^{35} cells, but the volume of the fluid, which waters them, constitutes merely 14 litres;

d) distribution of blood between the tissues can be regulated. One might suppose that the CO_2 levels would rise or the O_2 levels fall before the heart rate changes. Instead, the heart rate changes first. It is common knowledge that the muscle and joint movements occurring during exercise are reported to brain by sensory nerves. In turn, speed heart rate, increase return of the blood through the veins, etc. that maintain steady levels of ions and blood gases during the exercise, not lagging behind it. However, such distribution (or signal) is carried out not in response to the local deficit of O_2 or excess of CO_2. Then what can the sensory nerves report of to the brains: on the concentration of the respiratory gases, ions or of some other things? We believe that the initial and passing ahead others stimulus for the sensory nerves so that the speed heart rate, perhaps, is the local increase of temperature in the functioning muscle tissues on account of which the organism tries to liquidate the emerged temperature difference in the body through accelerating the blood current – the far distance transferor of heat in the animals;

e) the skin breathing with the many vertebrates can be added and even be replaced by breathing with the lungs or gills;

f) the CS are lacking or underdeveloped with the sea animals. They have no erythrocytes in their hemolymph, Hb is in the dissolved state in it;

g) diving reflex in marine mammals; when being submerged in water their blood starts running towards their heart, skeleton muscles and brains. The contemporary guides' explanation of this phenomenon is that such distribution of blood is associated with the vital significance of these organs. We, doubting such element of the "awareness", associate all that is happening with the excess accumulation of heat when swimming in these actively functioning organs and the strive of the organism to level the differences of temperature all over the whole body.

And finally, in order that the CS could emerge the animals should decide at least another two problems:

1) overcoming of the surface/volume barrier in order to have sufficiently large dimensions (Ibraimov, 2004) and only then the gas exchange and nutrition through diffusion, pinocytoze, phagocytoze, etc., without the CS becomes insufficient;

2) in the body of such animals there already should be available the specialized cells, tissues or organs with different levels intensity of the metabolism due to which permanent parts in the body with the different temperature can appear, creating, thereby, the physical premises for the directed movement of the intercellular fluid. In other words, a possibility should appear so that the animals could canalize the thermal energy with the fluid current across the whole body for leveling the difference of temperature in the organism as the cell's ability to bypass the second low of thermodynamics, i.e. to canalize its energy instead of continually loosing order.

In this way, we believe that both the short and long transfer of the thermal energy in the process of evolution of the highest eukaryotes has undergone deep changes, the first towards increasing the physical BHC (Ibraimov, 2003, 2004), and the second through switching on the additional physiological functions. Namely, apart from heat, by the current of the circulating fluid the nutrients, ions, waste products, hormones, other substances, and blood cells started to transport, which in the final end brought to the emergence of the homoiotherms capable of supporting the high level of the metabolism and temperature homeostasis even under the conditions of cold environment having provided, thereby, the freedom of their movement on land, in air and at sea.

The following question may arise: is it so important to know the origin and evolution of the BHC of the animals and of man? Of course, it is still early to judge about it at least due to the fact that our knowledge on this question so far is extremely limited. Nevertheless, in our opinion, there exists a great deal of enigmas directly or indirectly connected with the evolution of the BHC and in final end with the thermoregulation in general. We can give just some examples.

1. We believe that the emergence of the BHC special form inherent only to the animal world was the revolutionary event: and the rates of the evolution of the large multi-cellulars have changed, also very important adaptive shifts took place. In particular, with the emergence of the LDTTE mechanisms, the possibility of emergence of more perfect systems of life-support such as blood circulation, the gills and lungs breathing, 4-cameras heart and the warm-bloodedness itself up to the homoiothermy has appeared.

2. The BHC in the form of the LDTTE might have an important significance in movement in space in the emergence of the phenomenon of the mobility of large Metazoa. In order to get convinced in this it is enough to recollect the dependency of the activity of insects, amphibians and reptiles on the temperature of the environment. The other convincing example which witnesses the possible role of the LDTTE serves the ability of some warm-blooded animals during hibernation under the conditions of the arctic winter and fish in the coastal waters of the Antarctic to work out antifreezes in order to keep blood in the fluid state.

3. Inflammation and similar diseases take place at all the stages of the animal world, but a special complexity it achieves with the highly organized animals. Inflammation as the important form of the protective reaction has become possible with the emergence of the blood- and lymph circulation, which in turn, may be, emerged as the consequence of the LDTTE. If the hypothesis on the possible role of the Q-HRs in strengthening the CC compactization turns out to be true and, hereby, will effect the BHC, then it becomes understandable why only the gorilla, chimpanzee, and human have a common cold, since exactly in their genome, apart from the C-HRs, there are the Q-HRs.

4. The heterochromatin can be presented in the form of the heterochromatin regions included in the chromosome, or in the form of additional B-chromosomes (Jones and Rees, 1982). It is not excluded that some kinds of birds and mammals support the intra population variability on the BHC, apart from all other things, changing the number of the B-chromosomes in the karyotype.

And, finally, (5) let’s discuss one more enigma of the BHC adaptive evolution with the warm-blooded vertebrates. Birds and mammals have developed diversified limb structures that permit many different locomotory styles and behaviors, yet until present there is no clear answer to the following questions: a) why the bones of the extremities of these animals are not spongy but tube as a rule? b) why haemopoiesis in the epiphysis with the adult animals happens? c) why diaphysis is filled with the fatty yellow marrow ?

From the simple biomechanical considerations it is evident that the bones, as the basis of the muscular-skeletal system, should be monolithic and not hollow, and the adult organisms could continue to make the haemopoiesis in the same organs where they were doing it in the mother’s womb before, that is, outside the epiphysis of the tube-bones. If it is important, apart from strength, to have lightness, the diaphysis cavity might have remained empty.

In our opinion, one of the possible answers to these questions is associated with the thermoregulation. Let’s imagine that the extremities of the warm-blooded organisms turned out to be in cold water and they are to remain warm enough, at least in order not to have convulsive contractions in the muscles. Of course, the CS will come to help. However, in practice, it is ineffective due to the weak vascularization of the bone tissue. Perhaps, due to this, nature came to a compromise settlement having yielded in the mechanical strength; the epiphysial parts of the tube-bones became the sources of the haemopoiesis where a high level of metabolism is being maintained, simul-taneously being the permanent additional source of heat for bone tissue, and the fatty yellow marrow in the diaphysis as a heat capacity substance promotes more lasting preservation of heat in the extremities. Of course, our proposal so far has not yet been strengthened by the corresponding experimental data. Nevertheless, there is one more ancient observation of cattle-breeders: the bone fat from the tube-bones of the phalanx becomes firm at low temperature considerably later than the one taken even from the humerus or femur. Naturally, it is associated with their chemical composition, possibly, with the high share of the non-saturated fat acids. However, the biological sense of the phenomenon itself seems to be quite evident: this part of the extremities of animals more frequently and longer is being subjected to the effect of cold; they are almost deprived of thermal insulation in form of the layer of the muscle tissue or the subcutaneous fat. Therefore, the fat that is inside these tube-bones should possess a high heat capacity in order to stay longer in the fluid state, when the animal's extremities are in the cold environment.

CONCLUSION

For unknown as yet reasons, at late stages of the evolution of life, in ancestor of contemporary three higher primates (*H. sapiens, P. troglodytes and G. gorilla*) there appeared a new type of constitutive heterochromatin – "Q-heterochromatin". Thus, one can say with certainty that Q-heterochromatin originated in tropical Africa. The bulk of existing data indicates that Q-HRs on chromosomes of these three primates have a common nature, only differing in the number, size and localization in the karyotype. But the main difference between these species is the presence of wide quantitative variability of chromosomal Q-HRs only in the genome of human populations (Chiarelli and Lin, 1972; Grouchy et al., 1973; Pearson, 1973, 1977; Seuanez et al., 1976; ISCN, 1978; Erdtmann, 1982; Ibraimov and Mirrakhimov, 1985).

Despite the fact that Q-HRs have been studied for over 30 years, their biological role in evolution and ontogenesis remain unclear. However, it is necessary to introduce several specifications here. The point is that for not properly understood reasons, and especially in the last two decades, constitutive heterochro-matin was taken by a vast majority of authors to mean mainly C-heterochromatin. Many even stopped to indicate the type of heterochromatin even when the object of their studies was man. Despite the fact that the stream of studies involving the heterochromatin part of the genome never ran short in the past and in recent years even began to grow in connection with the completion of the Human Genome Project and increased interest of investigators in the problem "redundant" DNA in eukaryotes, there are practically no publications specially devoted to Q-heterochromatin. This strange circumstance led to the fact that: a) all that is actually known about C-heterochromatin began to be attributed to constitutive heterochromatin; b) there appeared, it seems, a new generation of investigators, who take constitutive heterochromatin to be only C-heterochromatin or just a part of the genome containing highly repetitive DNA sequences; c) even electron journals ceased to consider works concerning Q-heterochromatin, since according to their newest notions Q-HR is something like the ex-USSR. Nevertheless, Q-HRs exists and still fluoresces brightly under a fluorescent microscope there where they have always been and where they were seen by cytogeneticists in the seventies and eighties of the XX centuries.

It could be that all this is due to the fact that the harvest collected in the first 10-15 years of studying chromosomal Q-heterochromatin was very scanty. In essence, in those years only methods of detection, localization, identification and classification of chromosomal Q-HRs (Paris Conference 1971, 1975; Geraedts and Pearson, 1974; Ibraimov et al., 1982), their prevalence in animals and man (Chiarelli and Lin, 1972; Grouchy et al., 1973; Seuanez et al., 1976; Pearson, 1973, 1977; ISCN, 1978), inheritance and segregation (Geraedts and Pearson, 1974; Phillips, 1977; Van Dyke et al., 1977; Robinson and Newton, 1977; McCracken et al., 1978), certain interracial (Lubs et al., 1977), inter population (Buckton et al., 1976; Ibraimov and Mirrakhimov, 1982 a, b, c; Stanyon et al., 1988) and inter individual (McKenzie and Lubs, 1975; Müller et al., 1975; Yamada and Hasegava, 1978; Al-Nassar et al., 1981) differences have been established. Some attempts to find any relation between localization or amount of chromosomal Q-HRs in the genome of man and his pathology were unsuccessful (Verma and Dosik, 1980; Ibraimov and Mirrakhimov, 1985; Verma, 1988).

Speaking to the point, it can already be considered that the existence of different amounts of Q-HRs in the genome of various individuals is a well established fact. But main question remains open: what does this mean to a concrete individual? For it is known that both complete absence and the maximum number of Q-HRs in the genome have no appreciable pathologic or other phenotypic manifestations. We maintain that: a) CC constitutes the structural basis for the BHC physical component; b) chromosomal Q-HRs within the CC effects the human body heat conductivity; c) decreases in the amount of Q-HRs in individuals with age explained by different survival of neonates and infants depending on heat conductivity of their body; d) the amount of Q-HRs in the genome of man most probably has an impact of his vulnerability to certain "diseases of civilization" such as atherosclerosis, obesity, alcoholism and drug addiction; e) the amount of Q-HRs in the genome of an individual possibly effects his adaptation to the prolonged effect of cold, certain sports and professional activity through body heat conductivity (Ibraimov, 1993, 2002 a, b, 2004; Ibraimov and Mirrakhimov, 1982 a, b, c; Ibraimov and Karagulova, 2002, 2006; Ibraimov et al., 1986, 1991, 1997, 2002).

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