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Research Article

Arrangement of Human Cell Metaphase Chromosomes on the Equatorial Plate

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ABSTRACT

Chromosome is an important hereditary material that maintains the genetic stability of an organism. The structure and location of different chromosomes in the cell governs the basis, how it expresses the genetic effects in the cell and thereby in the whole organism. The chromosome territories (CTs) suggest the location of the chromosomes within the cell by analyzing the karyotypes of human cells. We assume the location and arrangement of chromosomes in the cells is by the interrelationship between chromosomes. More than 100 years ago a Cytologist named Theodor, proposed the idea of chromosome territories. It is indicated that chromosomes are not randomly distributed in Metaphase. This hypothesis is still not directly supported by any laboratory work. We have found in our clinical research that there is a high degree of karyotype expression, so we took a supportive position on this hypothesis but, in order to find the existence of such interrelationships between chromosomes, we conducted a statistical analysis of a large number of existing karyotypic data. In analyzed data we found a clear dominance of long arm over short arm of chromosome according to its activity, with exceptions in specific chromosomes. From the chromosomes statistical data that karyotype occurring between the short arms is relatively small then that of long arm. From the present data it was clear that the exchange of genetic material between the long-long arm is > than exchange of genetic material among long-short arm and short-short arm of the chromosome. Based on the frequency of chromosomal material exchange patterns for arrangement can be considered as circular arrangement, or honeycomb arrangement.

Keywords: Chromosome territories; Metaphase; Karyotype expression; Statistical analysis

INTRODUCTION

With few exceptions [1], genomes of living organisms are made of several segments of DNA, they together form a highly organized structure called chromosome. Chromosomes have highly packed DNA that interacted with basic proteins i.e., histones and non-histone, which also play a significant role in the regulation of gene expression [2]. Thus, Chromosomes are genetic vehicles, which facilitate the reproduction and maintenance of a specie's traits [3,4]. Theodor a cytologist in 1909 for the first time introduced the term chromosome territory [5], and currently several reviews have focused on this topic [6].

Two models have been proposed that explained different aspects of nuclear Chromosome territory distribution [7]. One model is based on the radial arrangement of CTs found in various types of mammalian cells suggests that gene-dense chromosomes are located more internally as compared gene-poor ones [8-10]. However, in non-cycling cells no such arrangement was found by Bridger et al. [11]. The second model proposed a specific neighbourhood relationship between distinct chromosome domains [7]. However, none of the above models have succeeded in proving beyond any doubt the actual mechanism of the chromosome arrangement.

It is imperative to note that, most of the diseases due to genetic defects are directly related to the chromosomal abnormalities. These abnormalities can be better understood by cytogenetics, the field that deals with the structure and properties of chromosomes and cell division, which is based on various methods, one of them known as "karyotyping." It is a photographic representation of chromosomes organized in a standard manner. For the first in 1960, fibroblasts were used for karyotyping [12]. Karyotypes are

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prepared from mitotic cells that are arrested in the metaphase state of the cell cycle, the stage when chromosomes reassume their condensed from. As a source of these cells a variety of tissue can be used. In order to diagnose cancer, typical specimens include bone marrow samples or tumour biopsies [13]. With the development of karyotyping, it has made possible to visualize previously undetectable chromosomal abnormalities such as small deletions of chromosomes and translocations between minute segments of chromosomes with each other [14].

The aim of the current study is to demonstrate to certain extent that the location and arrangement of chromosomes in metaphase in the cells is established by the interrelationship between chromosomes based on karyotype expression data analysis. Further, this analysis may shed light on the understanding of mechanism involved in chromosomal defects in rearrangements and possibly the derivation of methods to prevent them.

RESEARCH METHODOLOGY

We selected data from the National Cancer Institute [15], database on April 26, 2017. There were 10,676 karyotypes of the data sets, with 66,919 cases including karyotype analysis data within chromosomes and among chromosomes. Then we segregated karyotypic analysis data in which the exchange of materials takes place between chromosomes. The data of conventional karyotyping was selected, while the data of complex karyotyping was excluded. Complex karyotyping has its special significance, but in the present condition, there is some interference to the analysis of the data which would be analyzed in the future. Finally, a total of 43,368 valid data sets were collected.

The segregated data sets contains the specific information such as the chromosome number, the long arm and short arm of the chromosome and chromosome division and summarized results. Because of chromosome difference in the gender we calculated the sex chromosomes, X and Y respectively (the statistical data of X chromosome shows a slight increase but has little effect). All data were obtained by means of ordinary accumulation.

RESULTS

Chromosomes short and long arms arrangement.

We have found that there is an exchange of materials between the long - long arms, short - long arms and both short arms of chromosome. The high frequency exchange rate was found for long- long arms and short- short arms. It is suggestive that the arrangement of chromosomes in the cells may not be arranged in an "ordered" way, the long arm and the short arm of the chromosome float freely in the cytoplasm of cell during the metaphase. We divided the chromosomes into region 1 and non 1 region to observe the dominance of karyotype analysis data (Tables 1 and 2).

Let's look at the impact of partitioning on karyotype analysis. Different chromosomes are also divided into different regions. We divided chromosomes into 1 region and non-1 region to observe the dominance of karyotype analysis data. Non-1 region contain regions contains zones 2, 3 and 4, of the chromosome. Since most chromosomes in the short arm have only one region and no other region, the long arm has more than two regions, but there are eight zone in the third region and only four zone in the long arm of chromosome No,1. So we look at the long arm data. The data of the short arm was 11:13, which was relatively close, while the data of long-long arm was 3:21, which showed an obvious difference. It

Table 1: Karyotype analysis by chromosome long arm short arm, division summary.

		Summary		20	99	2		25	89	2	5		6	2			2	9	2		10	6			12		291
	P	Non 1 region		18	99			18		2	2														12		151
		1 region		2		2		7	89		3		6	2			2	9	2		10	6					140
		Non 1 region	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	x	y	
		1 region							9	2	2	2		3	2	7	5	2	4		4			68			110
1P			56	10	8		3	2	13	18	10	2	37	26	11	42		2	24				2				266
	Q	Summary	56	10	8		3	2	22	20	12	4	37	29	13	49	5	4	28		4		2	68			376
			56	30	107	2	3	27	111	22	17	4	43	31	13	49	7	13	30	0	14	6	2	68	12	0	667
		Non 1 region																									
		Summary	14						2		4			9				6		5							40
			12						2		2																16
	P	1 region	2								2			9				6		5							24
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	x	y	
		1 region								2			3			3					4			6		2	20
		Non 1 region	2		49	4	93		29	101		2	38			52			2	18							390
2P	Q	Summary	2		49	4	93		29	103	2	2	41			55			2	18	4			6		2	412
			16	0	49	4	93	0	31	103	6	2	41	9	0	55	0	6	2	23	4	0	0	6	0	2	452
		Summary	2		15	2	2	7				2	2	4							2						38
		Non 1 region	2		15																						17
	P	1 region				2	2	7				2	2	4							2						21

			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	x	y	
		1 region					34			13	2													2			51
		Non 1 region	3	9	2		61	2	2	85		2		2	2	8	4		2				2				186
3P	Q	Summary	3	9	2		95	2	2	98	2	2		2	2	8	4		2				2	2			237
			5	9	17	2	97	9	2	98	2	4	2	6	2	8	4	0	2	0	2	0	2	2	0	0	275
		Summary	2		2				2								2		4								12
		Non 1 region																									0
	P	1 region	2		2				2								2		4								12
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	x	y	
		1 region	2		2														2					3			9
		Non 1 region	7		10			2								35											54
	Q	Summary	9		12			2								35			2					3			63
4P			11	0	14	0	0	2	2	0	0	0	0	0	0	35	2	0	6	0	0	0	0	3	0	0	75
		Summary	2		4				3										14								23
		Non 1 region																									0
	P	1 region	2		4				3										14								23
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	x	y	
		1 region	3		2				6	10							15		19		4						59
		Non 1 region	2				2						2			2											8
5P	Q	Summary	5		2		2		6	10			2			2	15		19		4						67
			7	0	6	0	2	0	9	10	0	0	2	0	0	2	15	0	33	0	4	0	0	0	0	0	90
		Summary	25		7				2		8			2	2				2	2	2						52
		Non 1 region	18						2		8																28
	P	1 region	7		7									2	2				2	2	2						24
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	x	y	
		1 region	7		6					5									2		8						28
		Non 1 region		2	5	2	2	2	6	9	146	15	10	6	3	71	2		2								283
	Q	Summary	7	2	11	2	2	2	6	14	146	15	10	6	3	71	2		4		8						311
6P			32	2	18	2	2	2	8	14	154	15	10	8	5	71	2	0	6	2	10	0	0	0	0	0	363
		Summary	83	2		2	3				46		82	19				2	5		2						246
		Non 1 region		2																							2
	P	1 region	83			2	3				46		82	19				2	5		2						24
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	x	y	
		1 region	258				2				6		4			9			8					8			295
		Non 1 region	5		4			2	20	2			2	2	2	10			6				4				59
	Q	Summary	263		4		2	2	20	2	6		6	2	2	19			14				4	8			354
7P			346	2	4	2	5	2	20	2	52	0	88	21	2	19	0	2	19	0	2	0	4	8	0	0	600
		Summary	2								14		3	5				117	12					2			155
		Non 1 region	2								14																16
	P	1 region											3	5				117	12					2			139
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	x	y	
		1 region	3		2					6				2	16	2			2		6			15			54
		Non 1 region	10							7	10			4		2			2				5				40
		Summary	13		2					13	10			6	16	4			4		6		5	15			94
8P	Q		15	0	2	0	0	0	0	13	24	0	3	11	16	4	0	117	16	0	6	0	5	17	0	0	249
		Summary	5	4				30	46	16	4		7	68	2		4		6	7		3		4			206
		Non 1 region	2	2				30		16	4																54
	P	1 region	3	2					46				7	68	2		4		6	7		3		4			152

			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	x	y	
		1 region	14						16		2			2	2		2			4		120	4	27			193
		Non 1 region	2	2						36	2		482	14	2	39	2						4				585
9P	Q	Summary	16	2					16	36	4		482	16	4	39	4			4		120	8	27			778
			21	6	0	0	0	30	62	52	8	0	489	84	6	39	8	0	6	11	0	123	8	31	0	0	984
		Summary			2																			6			8
		Non 1 region																									0
	P	1 region			2																			6			8
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	x	y	
		1 region	2										56	2													60
		Non 1 region	2										130		2	9			9								152
10P	Q		4	0	2	0	0	0	0	0	0	0	186	2	2	9	0	0	9	0	0	0	0	6	0	0	220
		Summary	6		2				84	3	7			2	2		2		2				4	2			116
		Non 1 region																									0
	P	1 region	6		2				84	3	7			2	2		2		2				4	2			116
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	x	y	
		1 region		2	6			2	4	2	2	2	2	10		99					4	12		9			156
		Non 1 region	2	5	2	14	37		12				2			3			4								81
		Summary	2	7	8	14	37	2	16	2	2	2	4	10		102			4		4	12		9			237
11P	Q		8	7	10	14	37	2	100	5	9	2	4	12	2	102	2	0	6	0	4	12	4	11	0	0	353
		Summary	2	11	8			6	19	5	68		4		5	3	2	2	4	2	8		5		2		156
		Non 1 region																									0
	P	1 region	2	11	8			6	19	5	68		4		5	3	2	2	4	2	8		5		2		156
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	x	y	
		1 region	4	4		27	4	5	6	16	2		2	4	37	21	14		52	6	2	2		74			28
		Non 1 region	10	5	31		42	6	29	4	6	3				2	6	2	2				39				54
	Q	Summary	14	9	31	27	46	11	35	20	8	3	2	4	37	23	20	2	54	6	2	2	39	74			82
12P			16	20	39	27	46	17	54	25	76	3	6	4	42	26	22	4	58	8	10	2	403	74	2	0	984
		Summary						2			2			5	2	4	5						4	8			32
		Non 1 region																									0
	P	1 region						2			2			5	2	4	5						4	8			32
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	x	y	
	Q	1 region	4	2													2				2			2			12
		Non 1 region																									0
13P		Summary	4	2													2				2			2			12
			4	2	0	0	0	2	0	0	2	0	0	5	2	4	7	0	0	0	2	0	4	10	0	0	44
		Summary												3	4	4	5		2				7	7	2		34
		Non 1 region																									0
	P	1 region												3	4	4	5		2				7	7	2		34
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	x	y	
	Q	1 region	6										2	2			3		2								15
		Non 1 region																		2							2
14P		Summary	6										2	2			3		2	2							17
			6	0	0	0	0	0	0	0	0	0	2	5	4	4	8	0	4	2	0	0	7	7	2	0	51
		Summary	5			2	2				4		2	2	5	5		2	4				9	8			50
		Non 1 region																									0
	P		5			2	2				4		2	2	5	5		2	4				9	8			50

			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	x	y	
		1 region	23																		2	2		6			33
		Non 1 region																									0
	Q	Summary	23																		2	2		6			33
15P			28	0	0	2	2	0	0	0	4	0	2	2	5	5	0	2	4	0	2	2	9	14	0	0	83
		Summary	11	6					2	117		4		2			2										144
		Non 1 region																									0
	P	1 region	11	6					2	117		4		2			2										144
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	x	y	
		1 region	135						2	5			7	96			2		5			2	2	3			259
		Non 1 region	9		3				11		3		63	3									66				15
	Q	Summary	144		3				13	5	3		70	99			2		5			2	68	3			417
16P			155	6	3	0	0	0	15	122	3	4	70	101	0	0	4	0	5	0	0	2	68	3	0	0	2
		Summary	6			4	12		5	10	6		2	6		2		2		8		8					71
		Non 1 region																									0
	p	1 region	6			4	12		5	10	6		2	6		2		2		8		8					71
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	x	y	
		1 region	11		3	2	30			4	8		13		4		2		2	3		7	5	6			10
		Non 1 region	54									20	2					6									82
	Q	Summary	65		3	2	30			4	8	20	15		4		2	6	2	3		7	5	6			182
17P			71	0	3	6	42	0	5	14	14	20	17	6	4	2	2	8	2	11	0	15	5	6	0	0	253
		Summary		5				2			7			2					8								24
		Non 1 region																									0
	P	1 region		5				2			7			2					8								24
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	x	y	
		1 region	5	2											2			2	2			2		6			21
		Non 1 region	2																								2
	Q	Summary	7	2											2			2	2			2		6			23
18P			7	7	0	0	0	2	0	0	7	0	0	2	2	0	0	2	10	0	0	2	0	6	0	0	47
		Summary	6		2			2	2					5										2			19
		Non 1 region																									0
	P	1 region	6		2			2	2					5										2			19
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	x	y	
		1 region	45		2		2			2			9	2	2	2	2		2			2	2	5			79
		Non 1 region	475					5	2				334			11			28								850
	Q	Summary	520		2		2		2	2			343	2	2	13	2		30			2	2	5			929
19P			526	0	4	0	2	2	4	2	0	0	343	7	2	13	2	0	30	0	0	2	2	7	0	0	948
		Summary									3								2			34	2	2			43
		Non 1 region																									0
	P	1 region									3								2			34	2	2			43
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	x	y	253
		1 region	2			2				2			2		2	5			2	4		16		2			39
		Non 1 region	23							2																	25
	Q	Summary	25			2				4			2		2	5			2	4		16		2			64
20 P			25	0	0	2	0	0	0	4	3	0	2	0	2	5	0	0	4	4	0	50	2	4	0	0	107
		Summary											4	2	11		9					2	18	2			48
		Non 1 region																									0
	P	1 region											4	2	11		9					2	18	2			48

			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	x	y	
		1 region	4					2	2							2				2			2	4			18
		Non 1 region	4																								4
21P	Q	Summary	8					2	2							2				2			2	4			22
			8	0	0	0	0	2	2	0	0	0	4	2	11	2	9	0	0	2	0	2	20	6	0	0	70
		Summary								3	2		2		8	7	8					2	10	6			48
		Non 1 region																									0
	P	1 region								3	2		2		8	7	8					2	10	6			48
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	x	y	
		1 region	14							2					2	4		2				3					27
		Non 1 region	4						2		2																8
22P	Q	Summary	18						2	2	2				2	4		2				3					35
			18	0	0	0	0	0	2	5	4	0	2	0	10	11	8	2	0	0	0	5	10	6	0	0	83
		Summary	12			2						4		2		2											22
		Non 1 region	12																								12
	P	1 region				2						4		2		2											10
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	x	y	
		1 region															2			16		2		2			169
		Non 1 region	32											2		42		3	24								103
XP	Q	Summary	32											2		42	2	3	24	163		2		2			272
			44	0	0	2	0	0	0	0	0	4	0	4	0	44	2	3	24	163	0	2	0	2	0	0	294
		Summary																									0
		Non 1 region																									0
	P	1 region																									0
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	x	y	
		1 region																									0
		Non 1 region														14											14
		Summary														14											14
YP	Q		0	0	0	0	0	0	0	0	0	0	0	0	0	14	0	0	0	0	0	0	0	0	0	0	14
		Summary	56	8	9	9	5	7	263	13	20	4	2	14	4	6	53	142	20	7	52	8	8	18	32		1234
		Non 1 region	56	8	9				5	10	6														32		126
	P	1 region				7	5	7	258	3	14	4	2	14	4	6	53	142	20	7	52	8	8	8			1106
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	x	y	
		1 region		2	4		5	10		12	12		2	2	11	5		53	9	2	21	7	13	20		4	194
		Non 1 region		21	10	21	10	18	9	4	13	12	43	18	20	39	7	67	8	11			20		2		353
1Q	Q	Summary		23	14	21	15	28	9	16	25	12	45	20	31	44	7	120	17	13	21	7	33	20	2	4	547
			56	31	23	30	20	35	272	29	45	16	47	34	35	50	60	262	37	20	54	15	41	38	34	4	1781
		Summary	8		9			2			4		7	14	2			6		13							65
		1 region	6		9			2			2																19
	P		2								2		7	14	2			6		13							46
		1 region	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	x	y	
		Non 1 region								2			5		3						4			10	2	2	28
		Summary	23		15	4	4				5		3	8	56	10	3								4		135
	Q		23		15	4	4			2	5		8	8	56	13	3				4			10	6	2	163
2Q			31	0	24	4	4	2		2	9	0	15	22	58	13	3	6	0	13	4	0	0	10	6	2	228
		Summary	44	59	76	12	2	11	5	2			6	60				30	3		2						312
		Non 1 region	44	59	76			5	5																		189
	P	1 region				12	2	6		2			6	60				30	3		2						123

			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	x	y	
		1 region	4					5	2	7			2	2	2				2	2	2	2		52		2	86
		Non 1 region	10	15	376	4	61	8	31	31			2	43	8	141			14				146				890
3Q	Q	Summary	14	15	376	4	61	13	33	38			4	45	10	141			16	2	2	2	14	52		2	976
			58	74	452	16	63	24	38	40	0	0	10	105	10	141	0	30	19	2	4	2	146	52	0	2	1288
		Summary		4				2					14	23					2			2					47
		Non 1 region		4				2																			6
	P	1 region											14	23					2			2					41
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	x	y	
		1 region								2						2					8			13			25
		Non 1 region	21	4	4		2	2			2		670	2	2				4								713
		Summary	21	4	4		2	2		2	2		670	2	2	2			4		8			13			738
4Q	Q		21	8	4	0	2	4		2	2	0	684	25	2	2	0	0	6	0	8	2	0	13	0	0	4
		Summary	3	93	118		2	2	2				37	50					30		2						339
		Non 1 region	3	93	95			2																			193
	P	1 region			23		2		2				37	50					30		2						146
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	x	y	
		1 region	5		9								2	2	2	2			14		5		2	4			47
		Non 1 region	10	4	37	2	5		4			4	14	6		25			3	4			2				120
5Q	Q	Summary	15	4	46	2	5		4			4	16	8	2	27			17	4	5		4	4			167
			18	97	164	2	7	2	6		0	4	53	58	2	27	0	0	47	4	7	0	4	4	0	0	506
		Summary	2		2	2		2					2	11									2		3		26
		Non 1 region	2		2			2																	3		9
	P	1 region				2							2	11									2				17
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	x	y	
		1 region	8		5								2		2	2	2										21
		Non 1 region	15		6				4	3		2	119	4		13									2		168
	Q	Summary	23		11				4	3		2	121	4	2	15	2								2		189
6Q			25	0	13	2		2	4	3	0	2	12	15	2	15	2	0	0	0	0	0	2	0	5	0	215
		Summary	34	19	2			6	16		16		17	34				13			2		2	2			163
		Non 1 region	15	19	2			6	16																		58
	P	1 region	19								16		17	34				13			2		2	2			105
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	x	y	
		1 region			2						9		4	3	2	2			2		4	2		6			36
		Non 1 region	7		11		4	4		7	5	23	4	5	2	15	2	2									91
		Summary	7		13		4	4		7	14	23	8	8	4	17	2	2	2		4	2		6			127
7Q	Q		41	19	15	0	4	10	16	7	30	23	25	42	4	17	2	15	2	0	6	2	2	8	0	0	290
		Summary	20	103	96		10	17	2	32	38		2	18				5	4		2	6		2			357
		Non 1 region	18	10	85			12	2	26	38																282
	P	1 region	2	2	11		10	5		6			2	18				5	4		2	6		2			75

			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	x	y	
		1 region	12		7	2					6			6	2	10	6		9				8	203			27 1
		Non 1 region	4		31				7		6	4	4	4	5	10 61	4						17 30				28 60
	Q	Summary	16		38	2			7		12	4	4	10	7	10 71	10		9				17 38	203			31 31
8Q			36	10 3	134	2	10	17	9	32	50	4	6	28	7	10 71	10	5	13	0	2	6	17 38	20	0	0	34 88
		Non 1 region	12		2			13 6	6	12	4		6	10				3	4								19 5
		1 region	10					13 6	2	10	2																16 0
	P		2		2				4	2	2		6	10				3	4								35
		1 region	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	x	y	
		Non 1 region	12						9	6			2	3	2	2	6		4			4		37 25			37 75
		Summary	13	5		2			39	10	4	2	10	2	2		5		6				2				10 2
9Q	Q		25	5		2			48	16	4	2	12	5	4	2	11		10			4	2	37 25			38 77
			37	5	2	2		13 6	54	28	4	2	18	15	4	2	11	3	14	0	0	4	2	37 25	0	0	40 68
		Summary	8	2	2			15					2	3					20								52
		Non 1 region	6	2	2			15																			25
	P	1 region	2										2	3					20								27
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	x	y	
		1 region								2				2	2	2	2		2					12			24
		Non 1 region	12				6	2	23	4	2		5	9	6	75	2		2	2			4				15 4
		Summary	12				6	2	23	6	2		5	11	8	77	4		4	2			4	12			17 8
10 Q	Q		20	2	2	0	6	17	23	6	2	0	7	14	8	77	4	0	24	2	0	0	4	12	0	0	23 0
		Summary	43	43			2	10	10		50 2	23 6	2	2		2		23	15		37 9	2					12 71
		Non 1 region	41	38				10	6		50 2																59 7
	P	1 region	2	5			2		4			23 6	2	2		2		23	15		37 9	2					67 4
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	x	y	
		1 region	2				2	2	4		2			6	2	2	2		2		13			33 5			37 4
		Non 1 region	55	2	2	67 0	14	11 9	4	4	11	5		2		96 3	7	4	93	29			2		4		19 90
	Q	Summary	57	2	2	67 0	16	12 1	8	4	13	5		8	2	96 5	9	4	95	29	13		2	33 5	4		23 64
11Q			10	45	2	67 0	18	13 1	18	4	51 5	24 1	2	10	2	96 7	9	27	11 0	29	39 2	2	2	335	4	0	36 35
		Summary	41		2			2	2	6	18			2		2		99			4				2		18 0
		Non 1 region	28		2			2	2	4	16														2		56
	P	1 region	13							2	2			2		2		99			4						12 4
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	x	y	
		1 region	2		5		2		3	6	3	2	6	2	2		5		2	2				21			63
		Non 1 region	20	8	49	2	17	4	4	4	4	7	2			54			2								17 7
12Q	Q	Summary	22	8	54	2	19	4	7	10	7	9	8	2	2	54	5		4	2				21			24 0
			63	8	56	2	19	6	9	16	25	9	8	4	2	56	5	99	4	2	4	0	0	21	2	0	42 0
		Summary	13		2		2	3	2	16	4	2		17					4	2	2	2		2			73
		Non 1 region	11		2			3	2		2																20
	P	1 region	2				2			16	2	2		17					4	2	2	2		2			53

			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	x	y	
		1 region	11		2		2	2	2	2	2	2	2	8	14	33	17		9				12	8			12 8
		Non 1 region	20	56	8	2			2	5	3	6			6	6	2	2		2					2		12 2
13Q	Q	Summary	31	56	10	2	2	2	4	7	5	8	2	8	20	39	19	2	9	2			12	8	2		25 0
			44	56	12	2	4	5	6	23	9	10	2	25	20	39	19	2	13	4	2	2	12	10	2	0	32 3
		Summary	51	55	11	35	2	76	19	4	39	9	10 2	24							13	5	2	2	49	21	51 9
		Non 1 region	44	52	11			76	10	2	39														49		28 3
	P	1 region	7	3		35	2		9	2		9	10 2	24							13	5	2	2		21	23 6
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	x	y	
		1 region	5			2	2	2	2	9	2	2	54						6		18 9	18	13	27			33 3
		Non	29	10	13 8		25	8	15	10 93		7	94 8	48	11	63	2	13	2	17 27			2		4		41 45
14 Q	Q	Summary	34	10	13 8	2	27	10	17	11 2	2	9	94 8	48	65	63	2	13	8	17 27	18 9	18	15	27	4		44 78
			85	65	14 9	37	29	86	36	11 6	41	18	10 50	72	65	63	2	13	8	17 27	20 2	23	17	29	53	21	49 97
		Summary	5		4		9	2			4			13	2	3		2	2		2				2		50
		Non 1 region			4			2			2																8
	P	1 region	5				9				2			13	2	3		2	2		2				2		42
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	x	y	
		1 region	27					2		6	6	2	2	5	17	21	4		2		2		12	4			11 2
		Non 1 region	7	3					3	4	7	2	7		2	2			11 64				4				12 5
15 Q	Q	Summary	34	3				2	3	10	13	4	9	5	19	23	4		11 66		2		16	4			13 17
			39	3	4	0	9	4	3	10	17	4	9	18	21	26	4	2	11 68	0	4	0	16	4	2	0	13 67
		Summary	4									6		2				46	6	2				2			68
		Non 1 region	2																								2
	P	1 region	2									6		2				46	6	2				2			66
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	x	y	
		1 region	53																2					5			60
		Non 1 region	68						2				4		2	13			2				25				11 6
16 Q	Q	Summary	12						2				4		2	13			4				25	5			17 6
			12 5	0	0	0			2		0	6	4	2	2	13	0	46	10	2	0	0	25	7	0	0	24 4
		Summary	26	2	2	2	19	4	14	6		11	2	39		2	2	5	2		25	2			24		18 9
		Non 1 region	22	2	2			2	6	2															24		60
	P	1 region	4			2	19	2	8	4		11	2	39		2	2	5	2		25	2					12 9
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	x	y	
		1 region	9		2		14		2	9	4	2	2	6	15		4	2		32	2		10	16			13 1
		Non 1 region	8		14	5	3				11	2	93	2		7	12 22	2	9				2		2		13 82
17Q	Q	Summary	17		16	5	17		2	9	15	4	95	8	15	7	12 26	4	9	32	2		12	16	2		15 13
			43	2	16	7	36	4	16	15	15	15	97	47	15	9	12 28	9	11	32	27	2	12	16	26	0	17 00
		Summary	2	18	3						4			4					3			4	2		163		20 3
		Non 1 region	2	18																							20
	P	1 region			3						4			4					3			4	2		16 3		18 3

			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	x	y	
		1 region	2		2									2	2				30		2		6	33			79
		Non 1 region	11				4			2		2	29			17 8							4				17 60
18Q	Q	Summary	13		2		4			2		2	29	2	2	18 8			30		2		10	33			18 39
			15	18	5	0	4			2	4	2	29	6	2	17 8	0	0	33	0	2	4	12	33	16 3	0	20 42
		Summary	4	4	2		4	8		6			4	2	2		2										38
		Non 1 region	4		2			6		2																	14
	P	1 region		4			4	2		4			4	2	2		2										24
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	x	y	
		1 region	41		2	8	5		4				15	2		18 9	2		6	2	7			5			28 8
		Non 1 region																									0
	Q	Summary	41		2	8	5		4				15	2		18 9	2		6	2	7			5			28 8
19Q			45	4	4	8	9	8	4	6	0	0	19	4	2	18 9	4	0	6	2	7	0	0	5	0	0	32 6
		Summary									12 0		12	2			2	2	7	2	2			3	2		15 4
		Non 1 region									4																4
	P	1 region									11 6		12	2			2	2	7	2	2			3	2		15 0
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	x	y	
		1 region	7		2				2		2		2			18						32		2	2		69
		Non 1 region																									0
	Q	Summary	7		2				2		2		2			18						32		2	2		69
20 Q			7	0	2	0			2		12 2	0	14	2	0	18	2	2	7	2	2	32	0	5	4	0	22 3
		Summary	4		2				4	2	8			38 8				68	5		2		4				48 7
		Non 1 region	4		2				4	2	4																16
	P	1 region									4			38 8				68	5		2		4				47 1
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	x	y	
		1 region	13				2			8					12	12	12		10	6			4	17			96
		Non 1 region	18		14 6		2			17 22	2	4	2			2	4	25	2	4							19 33
	Q	Summary	31		14 6		4			17 30	2	4	2		12	14	16	25	12	10			4	17			20 29
21 Q Q			34	0	24 8	0	4		4	17 32	10	4	2	38 8	12	14	16	93	17	10	2	0	8	17	0	0	26 15
		Summary	68	6	4	3			11	19			9	56			6	3	6	2	4	2	4		2		20 5
		Non 1 region	10	2	4				11																2		29
	P	1 region	58	4		3				19			9	56			6	3	6	2	4	2	4				17 6
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	x	y	
		1 region	20	6	52	13	4		6	22 1	36 74	12	33 5	8	8	27	4	5	16	45	5	2	19	14			44 96
		Non 1 region																									0
22 Q	Q	Summary	20	6	52	13	4		6	22 1	36 74	12	33 5	8	8	27	4	5	16	45	5	2	19	14			44 96
			88	12	56	16	4		17	24 0	36 74	12	34 4	64	8	27	10	8	22	47	9	4	23	14	2	0	47 01
		Summary	2	4				2					4		2	2			2								18
		Non 1 region	2	4				2																			8
	P	1 region											4		2	2			2								10
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	x	y	
		1 region																			2						2
		Non 1 region																									0
X Q	Q	Summary																			2						2
			2	4	0	0		2			0	0	4		2	2			2		2	0	0	0	0	0	20
		Summary		2																							2
		Non 1 region																									0
	P	1 region		2																							2

			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	x	y	
YQ	Q	1 region	4		2																						6
		Non 1 region																									0
		Summary	4		2																						6
	P		4	2	2	0					0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8

Note: The following is a summary of the data we have collected a total of 43368 valid data. (Final summary table)

Table 2: Chromosome long arm, short arm summary.

1	P	56	30	107	2	3	27	111	22	17	4	43	31	13	49	7	13	30	0	14	6	2	68	12	0	667
	Q	56	31	23	30	20	35	272	29	45	16	47	34	35	50	60	262	37	20	547	15	41	38	34	4	1781
		112	61	130	32	23	62	383	51	62	20	90	65	48	99	67	275	67	20	561	21	43	106	46	4	2448
2	P	16	0	49	4	93	0	31	103	6	2	41	9	0	55	0	6	2	23	4	0	0	6	0	2	452
	Q	31	0	24	4	4	2		2	9	0	15	22	58	13	3	6	0	13	4	0	0	10	6	2	228
		47	0	73	8	97	2	31	105	15	2	56	31	58	68	3	12	2	36	8	0	0	16	6	4	680
3	P	5	9	17	2	97	9	2	98	2	4	2	6	2	8	4	0	2	0	2	0	2	2	0	0	275
	Q	58	74	452	16	63	24	38	40	0	0	10	105	10	141	0	30	19	2	4	2	146	52	0	2	1288
		63	83	469	18	160	33	40	138	2	4	12	111	12	149	4	30	21	2	6	2	148	54	0	2	1563
4	P	11	0	14	0	0	2	2	0	0	0	0	0	0	35	2	0	6	0	0	0	0	3	0	0	75
	Q	21	8	4	0	2	4		2	2	0	684	25	2	2	0	0	6	0	8	2	0	13	0	0	785
		32	8	18	0	2	6	2	2	2	0	684	25	2	37	2	0	12	0	8	2	0	16	0	0	860
5	P	7	0	6	0	2	0	9	10	0	0	2	0	0	2	15	0	33	0	4	0	0	0	0	0	90
	Q	18	97	164	2	7	2	6		0	4	53	58	2	27	0	0	47	4	7	0	4	4	0	0	506
		25	97	170	2	9	2	15	10	0	4	55	58	2	29	15	0	80	4	11	0	4	4	0	0	596
6	P	32	2	18	2	2	2	8	14	154	15	10	8	5	71	2	0	6	2	10	0	0	0	0	0	363
	Q	25	0	13	2	0	2	4	3	0	2	123	15	2	15	2	0	0	0	0	0	2	0	5	0	215
		57	2	31	4	2	4	12	17	154	17	133	23	7	86	4	0	6	2	10	0	2	0	5	0	578
7	P	346	2	4	2	5	2	20	2	52	0	88	21	2	19	0	2	19	0	2	0	4	8	0	0	600
	Q	41	19	15	0	4	10	16	7	30	23	25	42	4	17	2	15	2	0	6	2	2	8	0	0	290
		387	21	19	2	9	12	36	9	82	23	113	63	6	36	2	17	21	0	8	2	6	16	0	0	890
8	P	15	0	2	0	0	0	0	13	24	0	3	11	16	4	0	117	16	0	6	0	5	17	0	0	249
	Q	36	103	134	2	10	17	9	32	50	4	6	28	7	1071	10	5	13	0	2	6	1738	205	0	0	3488
		53	103	136	2	10	17	9	45	74	4	9	39	23	1075	10	122	29	0	8	6	1743	222	0	0	3739
9	P	21	6	0	0	0	30	62	52	8	0	489	84	6	39	8	0	6	11	0	123	8	31	0	0	984
	Q	37	5	2	2	0	136	54	28	4	2	18	15	4	2	11	3	14	0	0	4	2	3725	0	0	4068
		58	11	2	2	0	166	116	80	12	2	507	99	10	41	19	3	20	11	0	127	10	3756	0	0	5052
10	P	4	0	2	0	0	0	0	0	0	0	186	2	2	9	0	0	9	0	0	0	0	6	0	0	220
	Q	20	2	2	0	6	17	23	6	2	0	7	14	8	77	4	0	24	2	0	0	4	12	0	0	230
		24	2	4	0	6	17	23	6	2	0	193	16	10	86	4	0	33	2	0	0	4	18	0	0	450

11	P	8	7	10	14	37	2	100	5	9	2	4	12	2	102	2	0	6	0	4	12	4	11	0	0	353
	Q	100	45	2	670	18	131	18	4	515	241	2	10	2	967	9	27	110	29	392	2	2	335	4	0	3635
		108	52	12	684	55	133	118	9	524	243	6	22	4	1069	11	27	116	29	396	14	6	346	4	0	3988
12	P	16	20	39	27	46	17	54	25	76	3	6	4	42	26	22	4	58	8	10	2	403	74	2	0	984
	Q	63	8	56	2	19	6	9	16	25	9	8	4	2	56	5	99	4	2	4	0	0	21	2	0	420
		79	28	95	29	65	23	63	41	101	12	14	8	44	82	27	103	62	10	14	2	403	95	4	0	1404
13	P	4	2	0	0	0	2	0	0	2	0	0	5	2	4	7	0	0	0	2	0	4	10	0	0	44
	Q	44	56	12	2	4	5	6	23	9	10	2	25	20	39	19	2	13	4	2	2	12	10	2	0	323
		48	58	12	2	4	7	6	23	11	10	2	30	22	43	26	2	13	4	4	2	16	20	2	0	367
14	P	6	0	0	0	0	0	0	0	0	0	2	5	4	4	8	0	4	2	0	0	7	7	2	0	51
	Q	85	65	149	37	29	86	36	1106	41	18	1050	72	65	63	2	13	8	1727	202	23	17	29	53	21	4997
		91	65	149	37	29	86	36	1106	41	18	1052	77	69	67	10	13	12	1729	202	23	24	36	55	21	5048
15	P	28	0	0	2	2	0	0	0	4	0	2	2	5	5	0	2	4	0	2	2	9	14	0	0	83
	Q	39	3	4	0	9	4	3	10	17	4	9	18	21	26	4	2	1168	0	4	0	16	4	2	0	1367
		67	3	4	2	11	4	3	10	21	4	11	20	26	31	4	4	1172	0	6	2	25	18	2	0	1450
16	P	155	6	3	0	0	0	15	122	3	4	70	101	0	0	4	0	5	0	0	2	68	3	0	0	561
	Q	125	0	0	0			2		0	6	4	2	2	13	0	46	10	2	0	0	25	7	0	0	244
		280	6	3	0	0	0	17	122	3	10	74	103	2	13	4	46	15	2	0	2	93	10	0	0	805
17	P	71	0	3	6	42	0	5	14	14	20	17	6	4	2	2	8	2	11	0	15	5	6	0	0	253
	Q	43	2	16	7	36	4	16	15	15	15	97	47	15	9	1228	9	11	32	27	2	12	16	26	0	1700
		114	2	19	13	78	4	21	29	29	35	114	53	19	11	1230	17	13	43	27	17	17	22	26	0	1953
18	P	7	7	0	0	0	2	0	0	7	0	0	2	2	0	0	2	10	0	0	2	0	6	0	0	47
	Q	15	18	5	0	4			2	4	2	29	6	2	1708	0	0	33	0	2	4	12	33	163	0	2042
		22	25	5	0	4	2	0	2	11	2	29	8	4	1708	0	2	43	0	2	6	12	39	163	0	2089
19	P	526	0	4	0	2	2	4	2	0	0	343	7	2	13	2	0	30	0	0	2	2	7	0	0	948
	Q	45	4	4	8	9	8	4	6	0	0	19	4	2	189	4	0	6	2	7	0	0	5	0	0	326
		571	4	8	8	11	10	8	8	0	0	362	11	4	202	6	0	36	2	7	2	2	12	0	0	1274
20	P	25	0	0	2	0	0	0	4	3	0	2	0	2	5	0	0	4	4	0	50	2	4	0	0	107
	Q	7	0	2	0			2		122	0	14	2	0	18	2	2	7	2	2	32	0	5	4	0	223
		32	0	2	2	0	0	2	4	125	0	16	2	2	23	2	2	11	6	2	82	2	9	4	0	330
21	P	8	0	0	0	0	2	2	0	0	0	4	2	11	2	9	0	0	2	0	2	20	6	0	0	70
	Q	34	0	248	0	4		4	1732	10	4	2	388	12	14	16	93	17	10	2	0	8	17	0	0	2615
		42	0	248	0	4	2	6	1732	10	4	6	390	23	16	25	93	17	12	2	2	28	23	0	0	2685
22	P	18	0	0	0	0	0	2	5	4	0	2	0	10	11	8	2	0	0	0	5	10	6	0	0	83
	Q	88	12	56	16	4		17	240	3674	12	344	64	8	27	10	8	22	47	9	4	23	14	2	0	4701
		106	12	56	16	4	0	19	245	3678	12	346	64	18	38	18	10	22	47	9	9	33	20	2	0	4784
x	P	44	0	0	2	0	0	0	0	0	4	0	4	0	44	2	3	24	163	0	2	0	2	0	0	294
	Q	2	4	0	0		2			0	0	4		2	2			2		2	0	0	0	0	0	20
		46	4	0	2	0	2	0	0	0	4	4	4	2	46	2	3	26	163	2	2	0	2	0	0	314

	P	0	0	0	0	0	0	0	0	0	0	0	0	0	14	0	0	0	0	0	0	0	0	0	0	14
y	Q	4	2	2	0					0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8
		4	2	2	0	0	0	0	0	0	0	0	0	0	14	0	0	0	0	0	0	0	0	0	0	22

should be suggested that the karyotype analysis data of the region far from the centromere in the chromosome was higher than that of the region close to the centromere, whether the region far from the centromere was suggested that it had a large degree of freedom for activity.

In addition to the quantitative differences, the range of activity in the non-1 region is also higher than the corresponding chromosome region 1. The range of activity in the non-1 region is higher than that in the 1 region, but this is not true for all chromosomes. In general, the non-1 region prevails. This indicates that the activity of the non-region 1 chromosome is greater than that of chromosome region 1. The non 1 and 1 region still have overlapping activity, which is inconsistent on each chromosome, more or less. There may be convergence over a larger sample.

Chromosome long arm and short arm activity (comparisons)

From the numbers of long arm and short arm of the chromosomes, we observed that, there is clear dominancy of long arm over short arm of the chromosomes with exceptions in specific chromosomes as shown in Table 3. The ratio of difference is 9:15, long arm being dominant. It has been seen from the data of Table 4, that the activity in long arm of chromosomes is higher than short arm, with the exceptions in specific chromosomes (chromosomes No, 2, 6, 7, 10, 12, 16, 19, X and Y) that show higher activity in short arm than long arm.

Karyotype analysis of the long and short arm of chromosomes

It was found from our analysis that there is no obvious regularity in the data from the long or short arms of the single chromosome and in the other single chromosomes, but in summary of karyotyping the long arm is more obvious than the short arm. The ratio of the number of genes that dominate the exchange of chromosome material is 22: 2, except for two, chromosomes 6 and 16 (Table 5). In the short arm of the chromosome, the exchange of chromosomes materials between the short arm and the long arm is found to be higher than that on the short arm and short arm, however in long arm the material exchanged between chromosomes occurring on long arms is greater than the number of chromosomal material exchanges occurring on long arms and short arms. Karyotyping data elucidates that the long arms have a definite advantage, and this may be due to the arm length of the chromosome. In the analysis of data, in order to eliminate the odd single data while analyzing the whole data, we sorted out the frequency of mass exchange between chromosomes, we analyzed the karyotype of each chromosome frequency by size, arranged in the first 24 calculation, and so on, (X, Y chromosome were calculated) (Figures 1A - 1X).

Chromosome segregation statistics between the long arms

From the chromosomes statistical data as shown in Tables 6A – 6D karyotype occurring between the short arms is relatively small, because the short arms of many chromosomes have no non-1 region. In the comparison of region 1 and non-region 1, it can be seen that the number of karyotypes covered by non-region 1 is more than that of region 1, and the specific data is in more than 1 zone, suggesting that the activity of the non 1 region is greater than the region 1, and they also have the same coverage. Data analysis of the short & long arm, long & short arm, long and long arm of the chromosomes are more obvious. It is further suggested that the coverage of non-1-region is much greater than the rest (Figure 2).

Aggregation of chromosome activity

In the karyotype's analysis for chromosomal aggregation, it was observed that long- short arm of the chromosomes overlap with each other in a certain range, meaning there is overlap between homologues and non-homologous chromosomal material exchanges, which strongly supports the concept of Boveri chromosome domain (chromosome territories) (Figures 3 and 4).

Intensity of chromosome activity

Since karyotype analysis is a clinical activity and we conduct karyotyping analysis of patients, mainly concerned on hematological tumors. Karyotype analysis was performed in patients with greater clinical relevance, such as deformity and infertility, those who have no special clinical significance of deformity were exempted. It was also governed by various factors of the patient profile. For example, the common karyotype of chronic myelogenous leukemia is t (9; 22) (q34; QLL), and the common karyotype of acute promyelocytic leukemia is t (15; 17) (q22; Q12), the data is surprisingly high in certain cases. We calculated the intensity of karyotype analysis, which can effectively reflect on chromosome activity and cumulative frequency of exchange between chromosome exchange intensity (Figure 5). To eliminate the chromosomal bias caused by the clinical factors of a single disease it is seen that the exchange intensities of chromosomes are different, but the active chromosomes are still relatively high in data, while some chromosomes are relatively conserved such as sex chromosomes X, the exchange rate of Y is relatively low, may be consistent with the relative sex chromosomes to maintain their genetic stability.

Possible arrangement of chromosomes in metaphase cells

Based on the frequency of chromosomal material exchange, the frequency is considered as a pair of chromosomes that are closer to each other. Patterns for arrangement can be considered as circular arrangement, or honeycomb arrangement (Figures 6 and 7). From the karyotyping data analysis X and Y chromosome expression is very minute and the rules are very difficult, but we found out in comparing their respective high-frequency data, Both X, Y and chromosome 14 have higher frequency, while the X chromosome and chromosome 18 has the highest frequency. Therefore, the sex chromosomes X and Y may be closer to chromosomes 14 and 18 in the cell as presented in Table 7.

Table 3: Chromosome long arm and short arm activity.

Comparison between short and long arms		
S. No	P	Q
1	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 19 20 21 X	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 X Y
2	1 3 4 5 7 8 9 10 11 12 14 16 17 18 19 22 Y	1 3 4 5 6 8 9 11 12 13 14 15 16 18 19 22 X Y
3	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 17 19 21 22	1 2 3 4 5 6 7 8 11 12 14 16 17 18 19 20 21 22 Y
4	1 3 6 7 14 15 17 22	1 2 3 5 6 8 9 11 12 13 14 17 19 20 22
5	1 3 5 7 8 11 14 15 17 19	1 2 3 4 5 6 7 10 11 12 13 14 17 18 19 21 22
6	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 17 18 19	1 3 4 6 7 8 10 11 12 13 14 15 21 X
7	1 2 3 4 5 6 7 8 9 11 12 13 14 16 17 19 21 22	1 2 3 5 6 7 8 9 11 12 13 14 15 16 17 19 20 21 22
8	1 3 8 9 11 12 13 14 16 17 19 21 22	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 1719 20 21 22
9	1 2 6 7 8 9 11 12 13 14 15 17 18 20 21 22	1 2 3 4 6 7 8 9 10 11 12 13 14 15 16 17 20 21 22
10	1 3 11 12 13 14 17 22	1 2 3 5 6 7 8 9 11 12 13 14 15 17 18 21 22
11	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 17 1920 21 22	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 X
12	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 X	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 22 X
13	1 2 6 9 12 13 14 15 19 21 22	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 X
14	1 11 12 13 14 15 17 18 21 22 X	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 X Y
15	1 4 5 9 11 12 13 14 16 17 19 20 21 22	1 2 3 5 6 7 8 9 10 11 12 13 14 15 16 1719 21 22 X
16	1 2 3 7 8 9 10 11 12 15 17 20 21 22	1 7 10 11 12 13 14 16 17 18 21 22
17	1 3 4 5 7 8 9 10 11 12 13 14 15 16 17 18 20 21 22	1 2 3 4 5 6 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 X
18	1 2 6 9 12 13 16 17 20 22	1 2 3 5 8 9 10 11 12 13 14 17 19 20 21 22 X
19	1 3 5 6 7 8 11 12 13 14 15 17 20 21 22	1 2 3 4 5 6 7 8 11 12 13 14 15 17 18 19 22
20	1 4 8 9 11 13 14 17 18 20 21 22	1 3 7 9 11 12 14 15 16 17 18 19 20 22 X
21	1 6 7 11 12 13 14 1518 20 21 22	1 3 5 7 8 9 10 11 12 13 14 15 16 17 18 19 21 22
22	1 7 8 9 11 13 14 15 16 20 21 22	1 2 3 4 5 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 X
X	1 4 10 12 14 15 16 17 18 20 22	1 2 6 11 13 14 17 19
Y	14	1 2 3

Table 4: Data comparison for long and short arms of chromosome.

S. No	P	Q
1	633	1834
2	470	179
3	489	1080
4	75	788
5	76	507
6	381	213
7	612	354
8	274	3520
9	961	4000
10	278	152
11	344	3598
12	928	394
13	53	313
14	44	5022
15	106	1389
16	587	194
17	202	1647
18	52	2072
19	991	302
20	88	237
21	83	2538
22	80	4780
X	295	24
Y	21	10
Summary	8123	35147

DISCUSSION

Chromosomes are considered natural unit of subdivision of complete genome. During mitosis chromosomes can easily be seen in cells as a highly condensed structures but for many years their morphological nature during interphase remained undefined [16]. Thus, it is particularly important to elucidate the arrangement of chromosome during metaphase based on karyotype expression.

Chromosome structure and arrangement in cells are only well observed in metaphase of cells. Karyotype analysis is a prompt examination of clinical diseases (O'Connor, 2008). In our results we evaluated that the exchange of material between chromosomes follows a certain rule that the exchange may occur only in chromosomes adjacent to or close to each other. Individual chromosomes are different, some are more active, some relatively quiet; the long arm and short arm of chromosome is free in the cytoplasm of the cells; activity of the long arm of chromosome is greater and dominant than short arm of chromosome (Tables 1, 3, 4) and (Figures 1A - 1X).

We also found that segregation far from the centromere in different regions of the arm is greater than the segregation near the centromere (many chromosomes do not have region other than zone 1, and these chromosomes are not mentioned) (Tables 6A - 6D). In our work we found both sex chromosomes (X and Y) to be very close to chromosome number 14 and 18 (Table 7). Previously Boyle et al. have revealed that the chromosome which is gene-rich (human chromosome 19) is positioned more central in nucleus than the equally sized chromosome 18 which is gene-poor. Boyle et al. also report that the chromosomes of different

Table 5: Comparison of long arms and short arms (karyotype analysis of chromosomes).

Long vs short arms			
S. No	**P**	**Q**	**Overlapping**
1	22	24	21
2	17	18	14
3	19	19	15
4	8	15	6
5	10	17	8
6	18	14	12
7	18	19	17
8	13	22	13
9	16	19	15
10	8	17	8
11	20	23	20
12	23	23	21
13	11	23	11
14	11	24	11
15	14	20	12
16	14	12	8
17	19	23	18
18	10	17	8
19	15	17	13
20	12	15	8
21	12	18	10
22	12	22	12
X	11	8	3
Y	1	3	0

Note: The Q 7th numerical value is 272, the 16tvalue is 262, and the 19th value is 547.

Figure 1a: Genetic material exchange frequency of P and Q arm of chromosome-1 and rest of chromosomes.

Note: P 8th numerical value is 103.

Figure 1b: Genetic material exchange frequency of P and Q arm of chromosome-2 and rest of chromosomes.

Note: Q 3rd Numerical value 452.

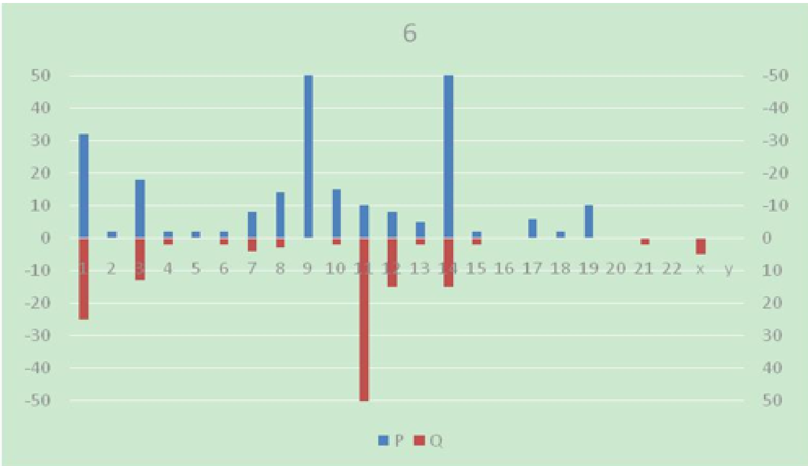
Figure 1c: Genetic material exchange frequency of P and Q arm of chromosome-3 and rest of chromosomes.

Note: Q 11th value is 684.

Figure 1d: Genetic material exchange frequency of P and Q arm of chromosome-4 and rest of chromosomes.

Note: Q 3 value is 164.

Figure 1e: Genetic material exchange frequency of P and Q arm of chromosome-5 and rest of chromosomes.



Note: the P 9th value is 154, the 14th value is 71, and the Q 11th value is 123.

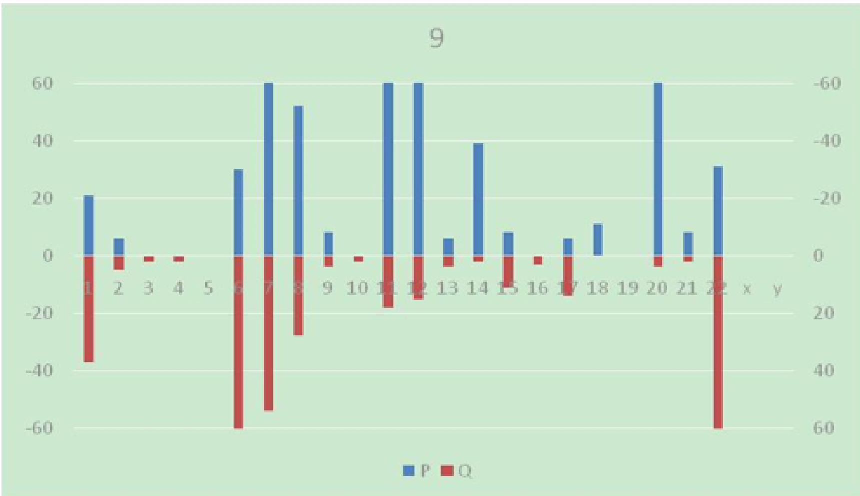
Figure 1f: Genetic material exchange frequency of P and Q arm of chromosome-6 and rest of chromosomes.

Note: The 1st value of P is 346.

Figure 1g: Genetic material exchange frequency of P and Q arm of chromosome-7 and rest of chromosomes.

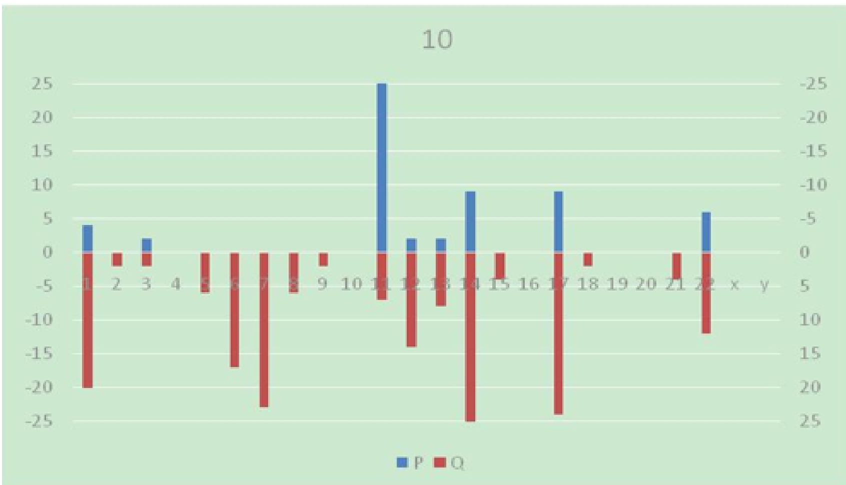
Note: The 2nd value of Q is 103, the 3rd value is 134, the 14th value is 1071, the 21st value is 1738 and the 22nd value is 205.

Figure 1h: Genetic material exchange frequency of P and Q arm of chromosome-8 and rest of chromosomes.



Note: P no. 7 value is 62, no. 11 is 489, no. 12 is 84, no. 20 is 123, and number 22 is 3725.

Figure 1i: Genetic material exchange frequency of P and Q arm of chromosome-9 and rest of chromosomes.



Note: P 11th value is 186, and Q 14th value is 77

Figure 1j: Genetic material exchange frequency of P and Q arm of chromosome-10 and rest of chromosomes.

Note: The 14th value of P is 102, the 4th value of Q is 670, the 6th value is 131, the 9th value is 515, the 10th value is 241, the 14th value is 967, the 17th value is 110, the 19th value is 392 and the 22th value is 335.

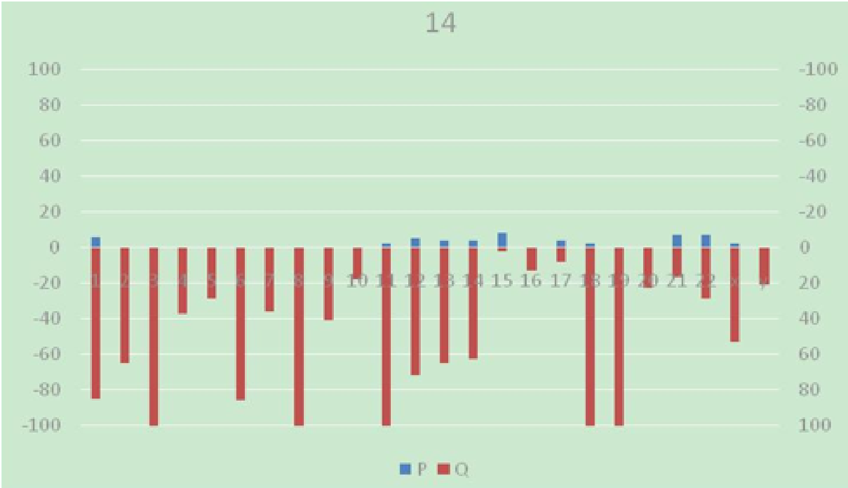
Figure 1k: Genetic material exchange frequency of P and Q arm of chromosome-11 and rest of chromosomes.

Note: P no. 21 has a value of 403.

Figure 1l: Genetic material exchange frequency of P and Q arm of chromosome-12 and rest of chromosomes.

Note: The 1st value of Q is 44, the second is 56, the 8th is 23, the 12th is 25, and the 14th is 39.

Figure 1m: The 1st value of Q is 44, the second is 56, the 8th is 23, the 12th is 25, and the 14th is 39.



Note: The 3rd value of Q is 149, the 8th value is 1106, the 11th value is 1050, the 18th value is 1727, and the 19th value is 202.

Figure 1n: Genetic material exchange frequency of P and Q arm of chromosome-14 and rest of chromosomes.

Note: The 17th of Q has a value of 1168.

Figure 1o: Genetic material exchange frequency of P and Q arm of chromosome-15 and rest of chromosomes.

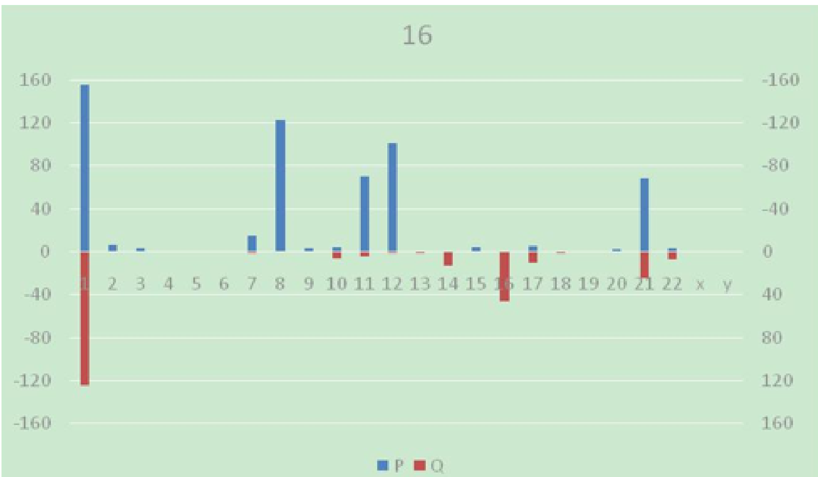


Figure 1p: Genetic material exchange frequency of P and Q arm of chromosome-16 and rest of chromosomes.

Note: Q no. 15 has a value of 1228.

Figure 1q: Genetic material exchange frequency of P and Q arm of chromosome-17 and rest of chromosomes.

Note: The value of Q is 1708 and the value of X is 163.

Figure 1r: Genetic material exchange frequency of P and Q arm of chromosome-18 and rest of chromosomes.

Note: Genetic material exchange frequency of P and Q arm of chromosome-19 and rest of chromosomes.

Figure 1s: Genetic material exchange frequency of P and Q arm of chromosome-19 and rest of chromosomes.

Note: The 9th item of Q has a value of 122

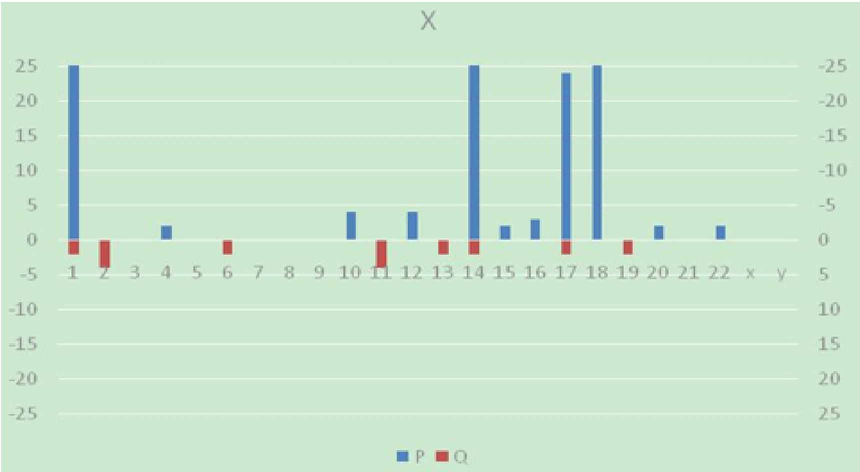
Figure 1t: Genetic material exchange frequency of P and Q arm of chromosome-20 and rest of chromosomes.

Note: The 1st value of Q is 34, the 3rd value is 248, the 8th value is 1732, the 12th value is 388 and the 16th value is 93.

Figure 1u: Genetic material exchange frequency of P and Q arm of chromosome-21 and rest of chromosomes.

Note: Value for Q 8th is 240, 9th is 3683 and 11th is 344.

Figure 1v: Genetic material exchange frequency of P and Q arm of chromosome-22 and rest of chromosomes.



Note: P 1st value is 44, 14this 44, and number 18this 163.

Figure 1w: Genetic material exchange frequency of P and Q arm of chromosome-23 and rest of chromosomes.

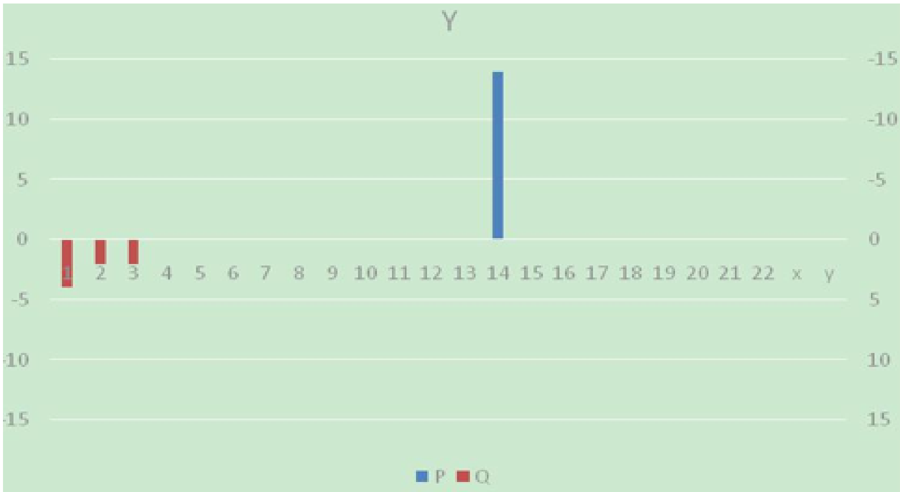
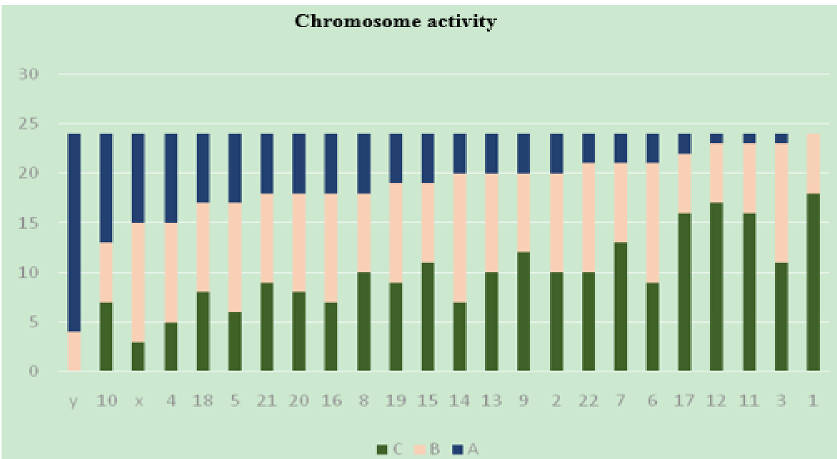
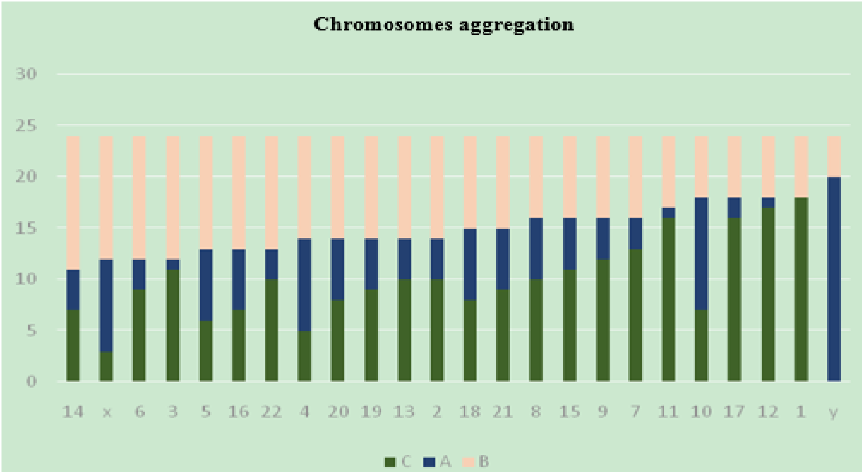


Figure 1x: Genetic material exchange frequency of P and Q arm of chromosome-24 and rest of chromosomes.



Note: Empty single double order. Genetic material exchange frequency of P and Q arm of chromosome-24 and rest of chromosomes.

Figure 2: Aggregation of chromosome activity.



Note: Empty single double order. However, chromosomes of the long arm or short arm of the same chromosome overlap with each other in a certain range of chromosomes, that is, there is overlap between homologues and non-homologous chromosomal material exchanges which strongly supports the concept of Boveri chromosome domain (chromosome territories).

Figure 3: Chromosomes aggregation.

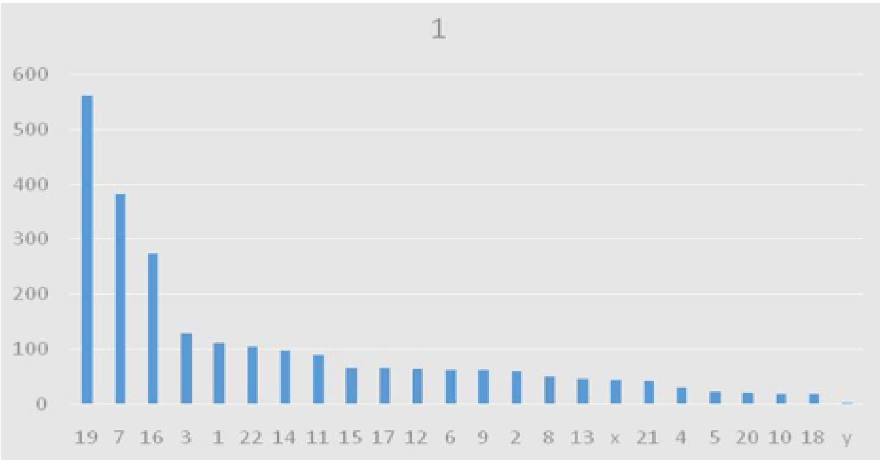


Figure 4a: Summary of karyotype analysis of chromosome no.1.

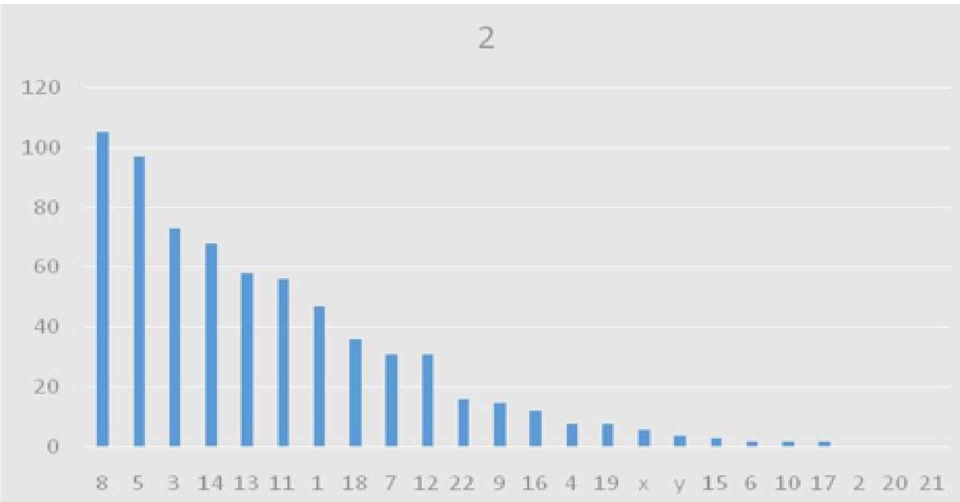


Figure 4b: Summary of karyotype analysis of chromosome no.2.

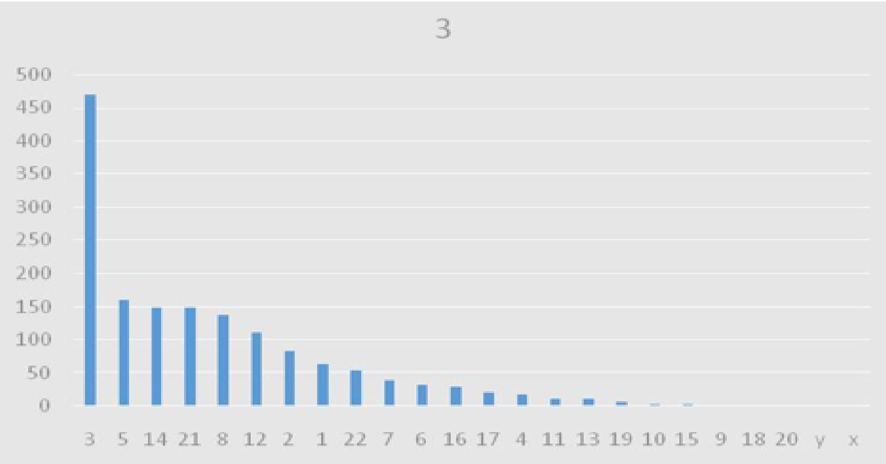


Figure 4c: Summary of karyotype analysis of chromosome no.3.

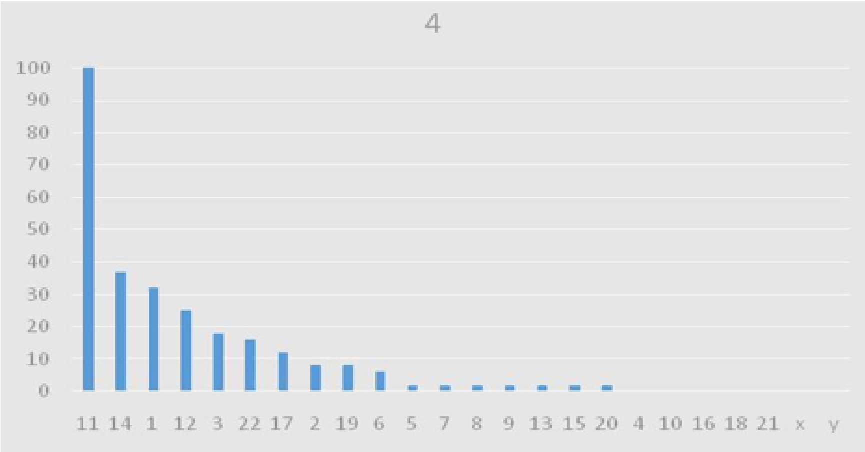


Figure 4d: Summary of karyotype analysis of chromosome no.4.

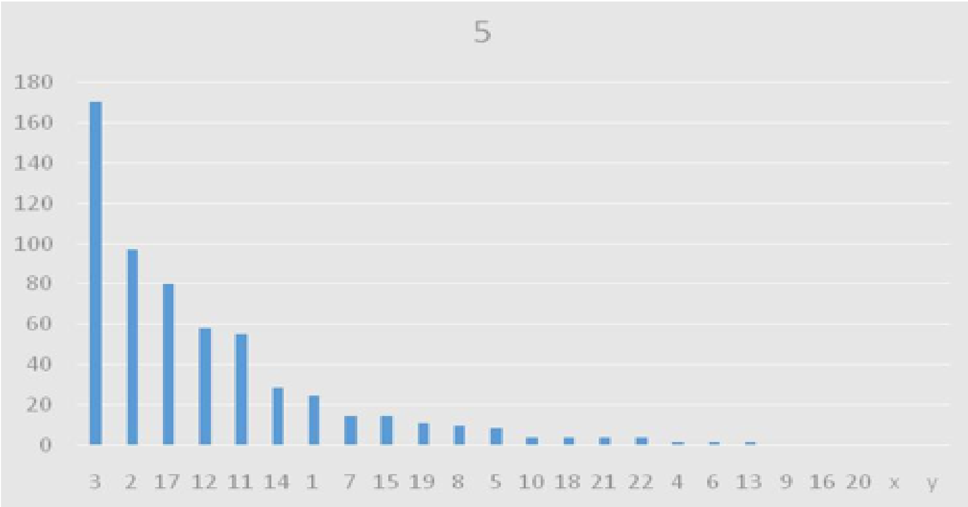


Figure 4e: Summary of karyotype analysis of chromosome no.5.

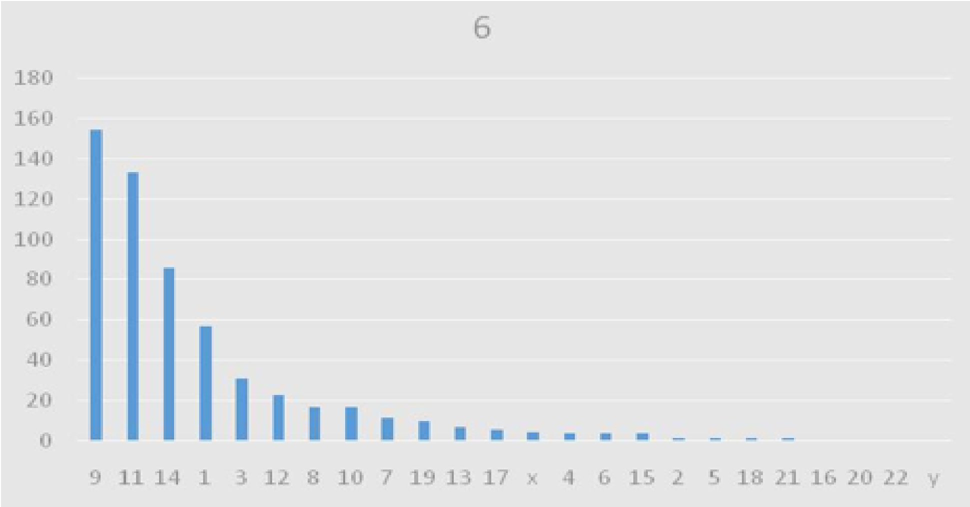


Figure 4f: Summary of karyotype analysis of chromosome no.6.

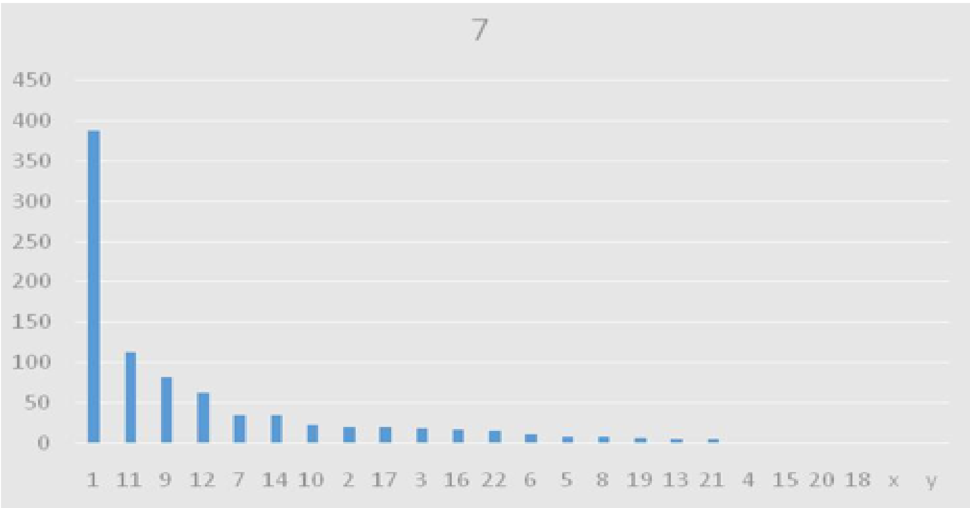
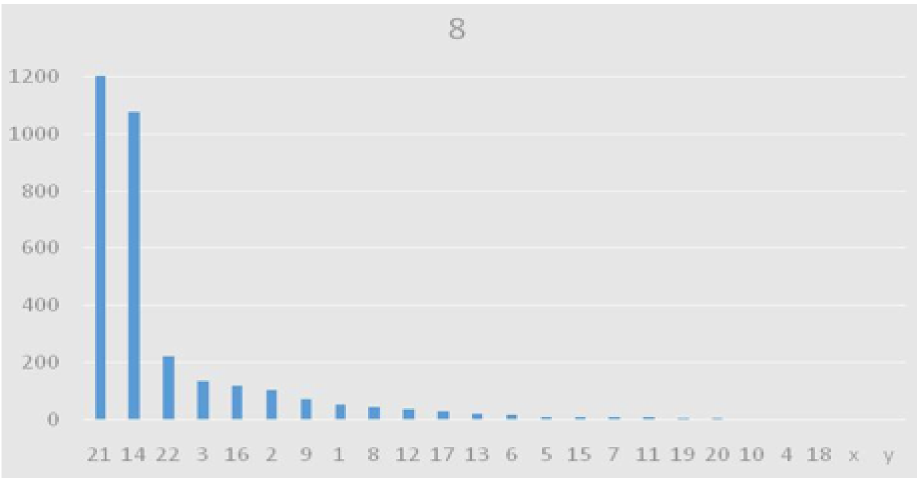
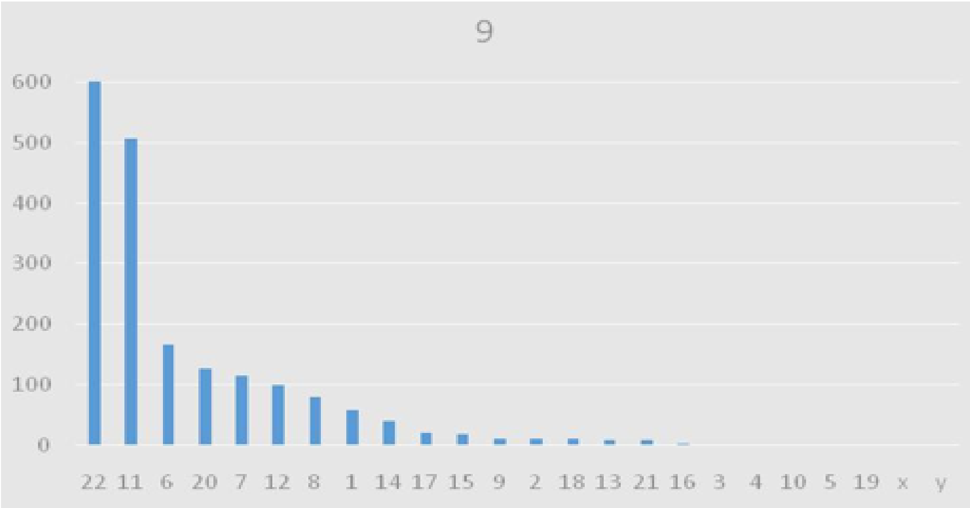


Figure 4g: Summary of karyotype analysis of chromosome no.7.



Note: Value of 21st is 1743.

Figure 4h: Summary of karyotype analysis of chromosome no. 8.



Note: Value of 22nd is 3756.

Figure 4i: Summary of karyotype analysis of chromosome no.9

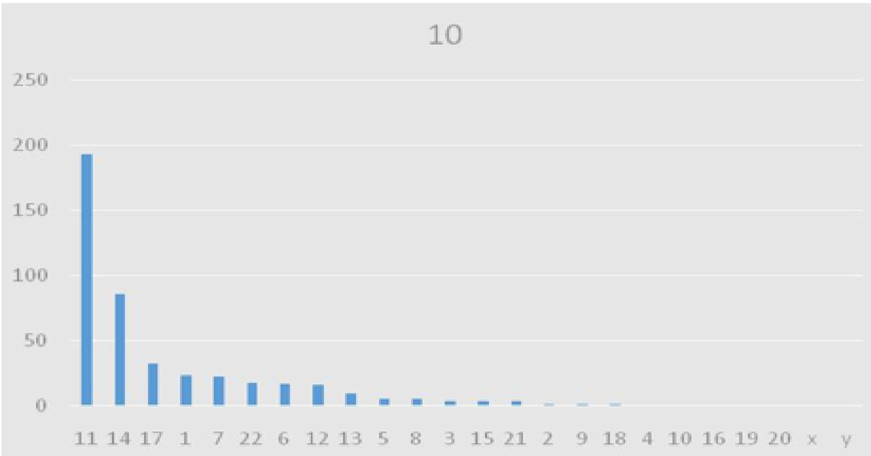
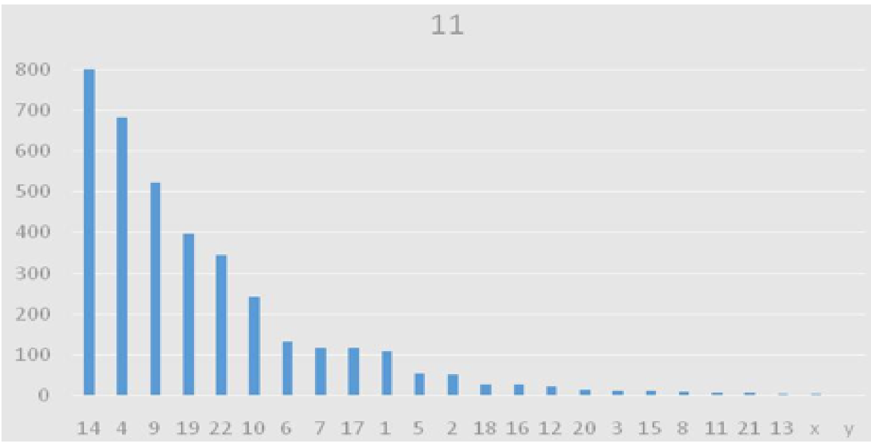


Figure 4j: Summary of karyotype analysis of chromosome no.10.



Note: Value of 14th is 1069.

Figure 4k: Summary of karyotype analysis of chromosome no.11.

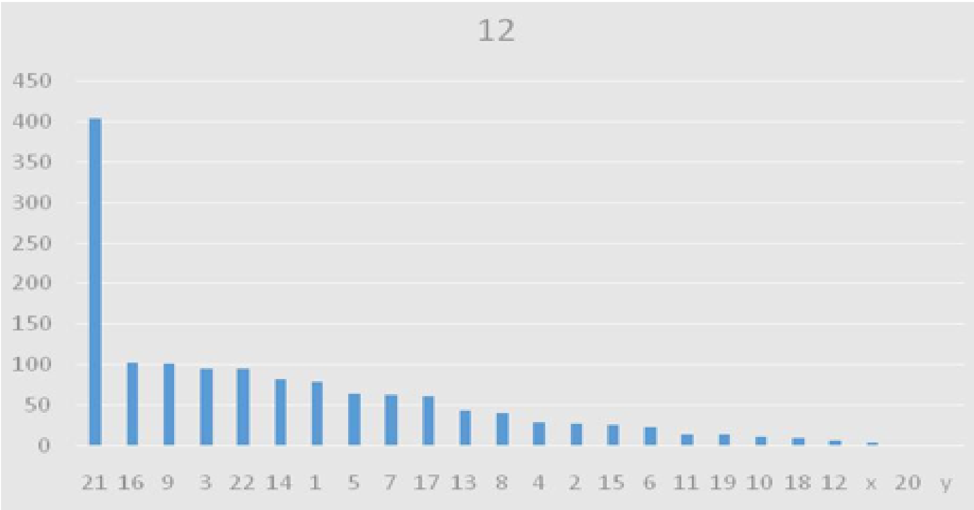


Figure 4l: Summary of karyotype analysis of chromosome no.12.

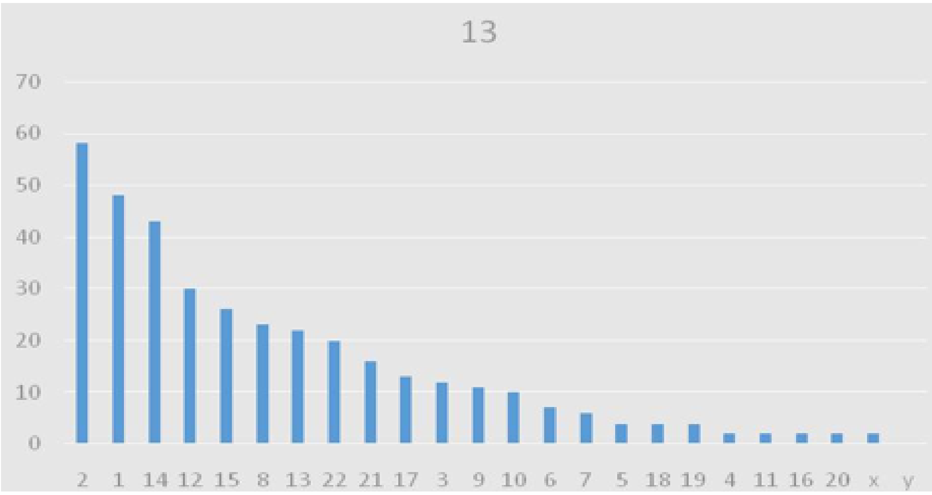
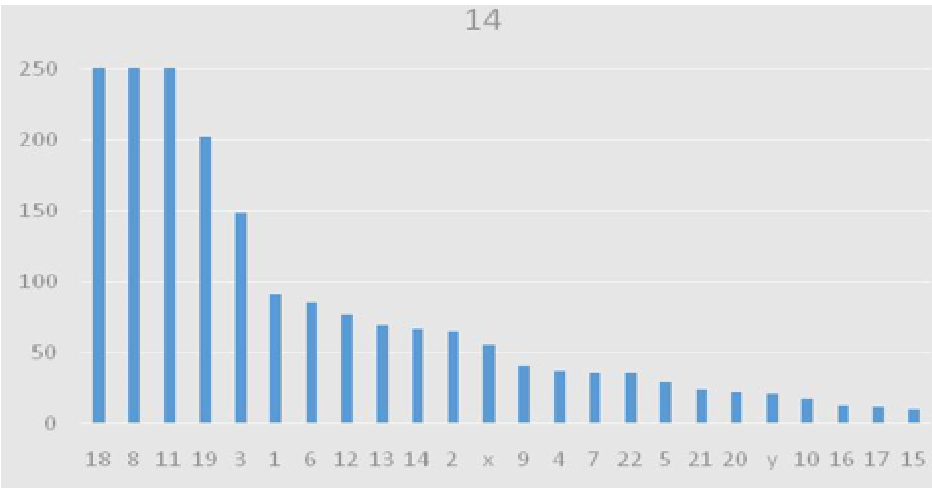
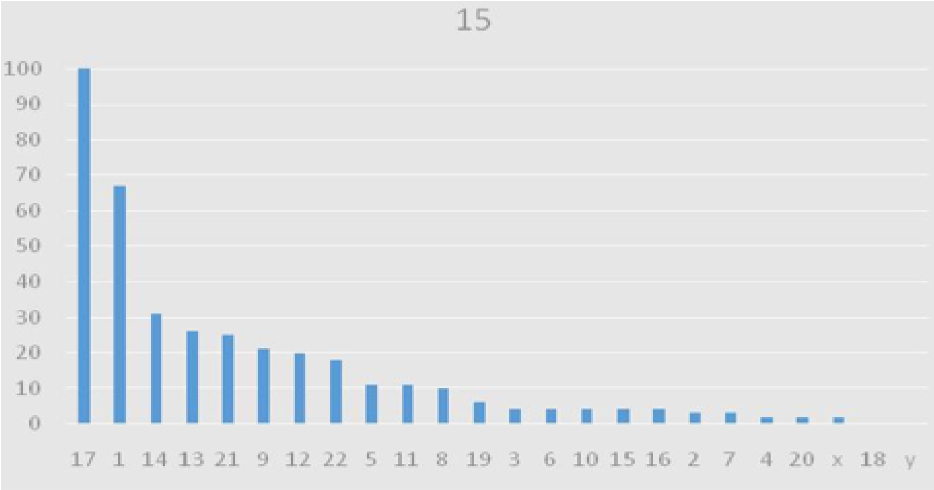


Figure 4m: Summary of karyotype analysis of chromosome no.13.



Note: The value of 18this 1729, the value of 8 is 1106, and the value of 11 is 1052

Figure 4n: Summary of karyotype analysis of chromosome no.14.



Note: Value of 17 is 1172.

Figure 4o: Summary of karyotype analysis of chromosome no.15

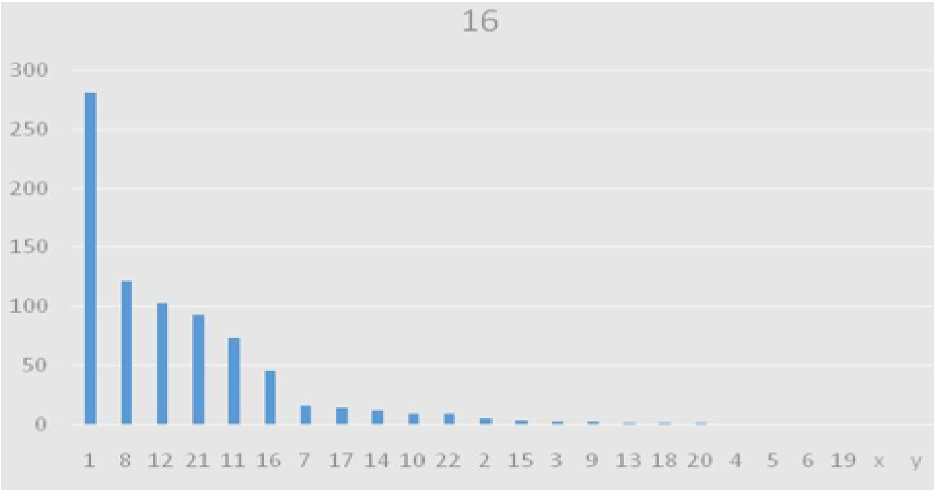
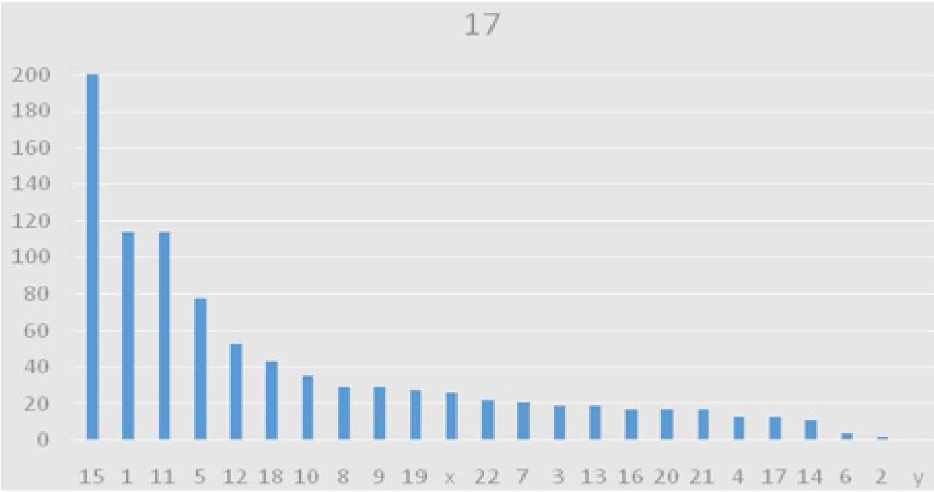
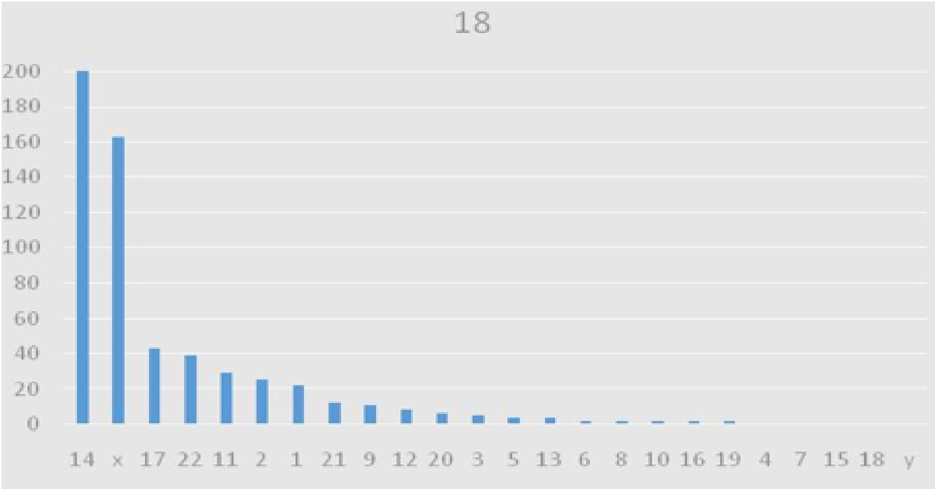


Figure 4p: Summary of karyotype analysis of chromosome.



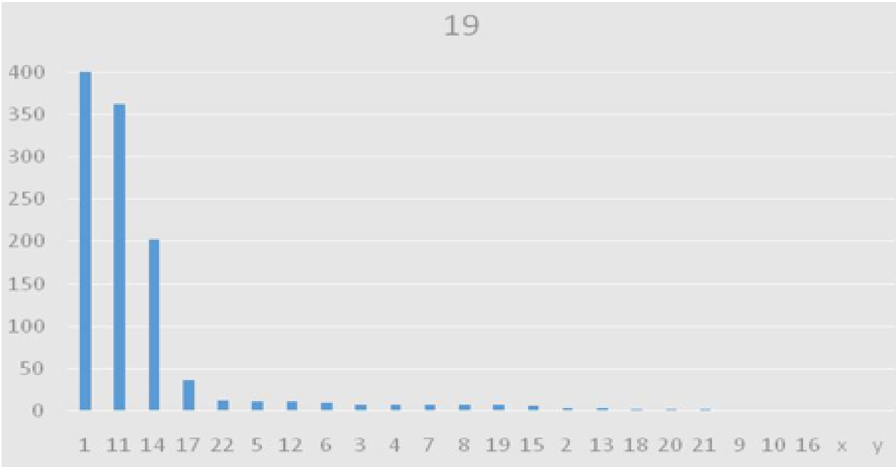
Note: Summary of karyotype analysis of chromosome no. 17.

Figure 4q: Value of 15 is 1230.



Note: Value of 17 is 1708.

Figure 4r: Summary of karyotype analysis of chromosome no.18.



Note: Value of 1 is 571

Figure 4s: Summary of karyotype analysis of chromosome no.19.

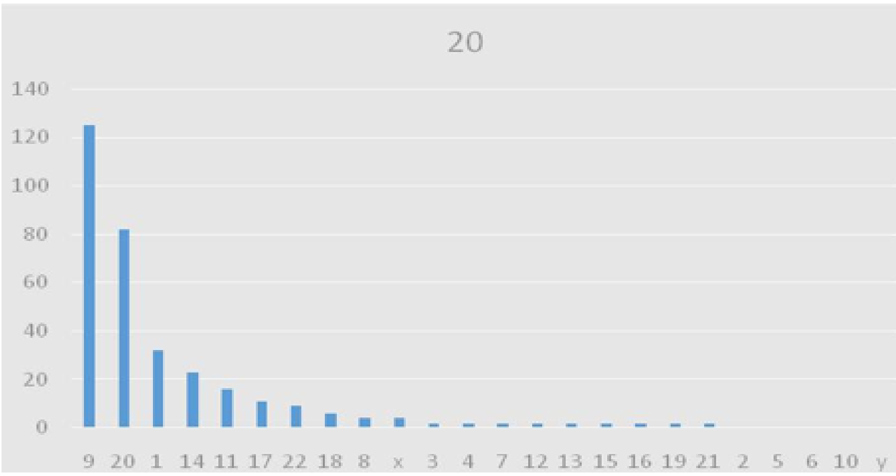
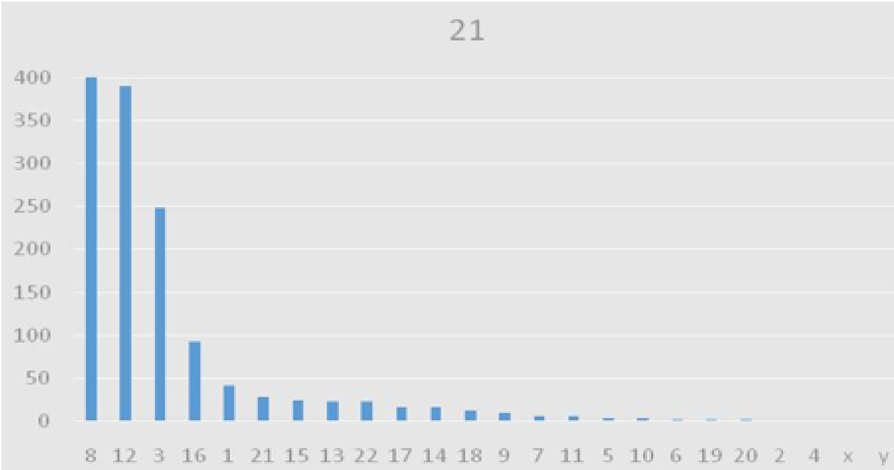
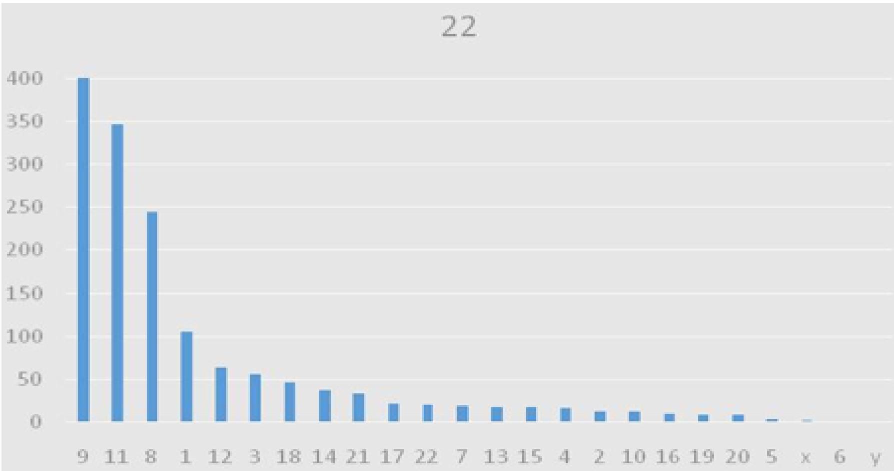


Figure 4t: Summary of karyotype analysis of chromosome no.20.



Note: Value of 8 is 1732.

Figure 4u: Summary of karyotype analysis of chromosome no.21.



Note: Value of 9 is 3678.

Figure 4v: Summary of karyotype analysis of chromosome no.2.

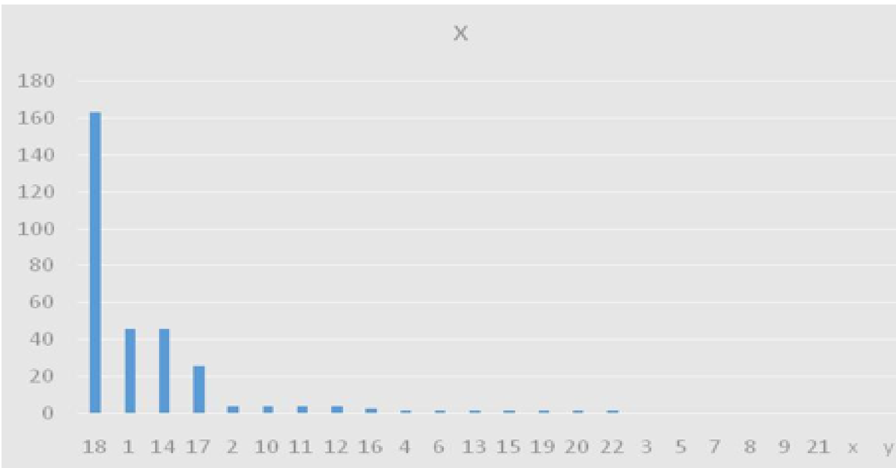


Figure 4w: Summary of karyotype analysis of chromosome X.

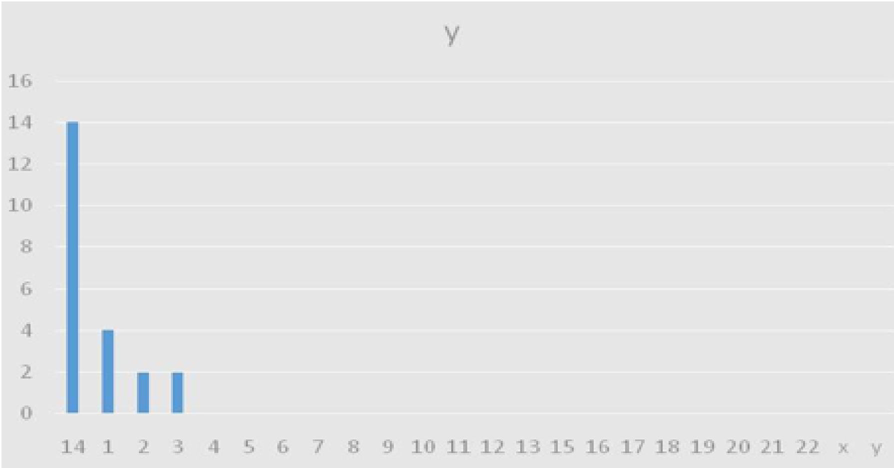


Figure 4x: Summary of karyotype analysis of chromosome Y.

Figure 5: Intensity of chromosome activity.

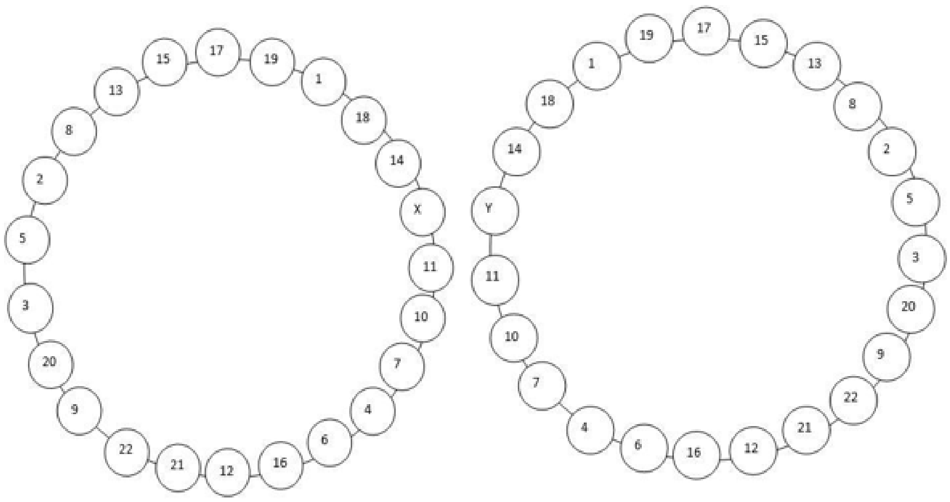


Figure 6: The arrangement of chromosomes in the cell equatorial plate honeycomb arrangement.

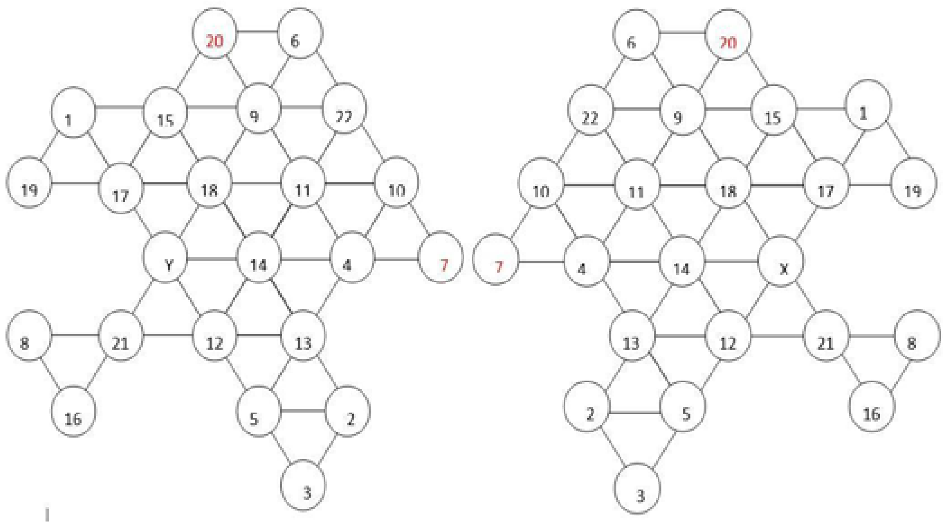


Figure 7: The arrangement of chromosomes in the cell equatorial plate honeycomb arrangement.

functional characteristics and having similar physical size adopt different positions nucleus [17].

So, from our work we conclude that, Arrangement of chromosomes in the cell occurred in a regular pattern. Through the massive karyotyping data, we found an exchange of chromosomal materials for adjacent chromosomes only. The present study suggested that patterns for arrangement of chromosome can be considered as circular arrangement, or honeycomb arrangement (Figures 6 and 7). According to the data analysis in Figures 4A to 4X) it is clear that chromosome No-1 show grater exchange of genetic material with chromosome No-7, 19, and 16. Chromosome No-1 also show low genetic material exchange with Chromosome No-X, Y and 15. Chromosome No-2 show grater exchange of genetic material with Chromosome No-8 and 13. Chromosome No-3 and 5 show grater exchange of genetic material for each other. Chromosome No-4 show grater exchange of genetic material with Chromosome No-11 but chromosome No-11 show grater exchange of genetic material wit chromosome No-10 and 14 in addition chromosome No-14 show grater exchange of genetic material with chromosome No-18 and Y-chromosome. Chromosome No-8, 21 and 15, 17 show grater exchange of genetic material for each other. Chromosome-X and 18 show grater exchange of genetic material.

CONCLUSION

The above discussed pattern of genetic material exchange is not possible in other form of arrangement than honeycomb arrangement. Due to honeycomb arrangements of chromosome it may be possible to exchange genetic material in such a way. In addition to the location of chromosomes, karyotyping may have some relationship with the structure of chromosomes, which needs further investigation. Through mathematical and statistical analysis of chromosome karyotype analysis, we re-recognized the value of karyotyping.

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