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Misconceptions of High School Students When Learning Genetics in the Republic of China

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INTRODUCTION

According to many research findings that genetics is one of the most important contents in biology, and also is one of the most difficult contents to teach and to learn (Finely, et al., 1982; Stewart, 1982). In the study of biology instruction in the Republic of China (Huang, 1987), it indicates that genetics is one of the topics that exists significant relationship between the teaching difficulty perceived by teachers and learning difficulty expressed by students. There are many researches study the misconceptions and teaching strategies on genetics (Deadman & Kelly, 1978; Emery, 1973; Hackling, 1981; Kargbo et al., 1980; Stewart & Dale, 1981; Walker et al., 1979; Hackling & Treagust, 1984). But there is no systematic study on genetics instruction and learning in the Republic of China. The researcher set a systematic study plan on genetics instruction and learning in high school level. It started with the evaluation of the learning situation on genetics in high school level, and ended with developing a teaching method in order to improve genetics instruction and learning. This study is a part of the systematic study. The purpose of this research is to

study the misconceptions of high school students when learning genetics in the Republic of China.

METHODOLOGY

Validation of the Instrument

After study the genetics learning situation by paper-pencil achievement test according to the contents of the biology textbooks (Huang, 1993), there was an interview instrument developed. The contents of this instrument were centered on these three areas: the recognition of the homologous chromosomes, the meiosis process of two pairs of chromosomes, and the relationships between genes, chromosomes and traits. The selection of these three content areas was according to the study findings (Stewart & Dale, 1981; Hackling, 1981) and researchers' experience.

The materials related to interview were: (1) a piece of paper: a large paper with circles indicated the mitosis cells and meiosis cells; (2) sticks: the blue color sticks and yellow color sticks, each color had two kinds of length, the short one (3 cm long) and long one (5 cm long). These sticks represented the chromosomes.

The contents of the instrument are listed in table 1. The validity is checked by content validity. The reliability is according to inter-rater reliability as .80 and 1.0.

Table 1

The content analysis of the interview instrument

Content areas	Item number	Total number
Recognition of homologous chromosomes	1-1 1-2	2
Meiosis process with two pairs of chromosomes		5
Duplication	2-1	
Results of the first division	2-2	
Results of the second division	2-3	
Synapsis	2-4	
Random assortment	2-5	
Relationships between genes, chromosomes, and traits		6
traits-number of gene	3-1	
genotype	3-2, 3-3	
genes-chromosomes	3-4, 3-5, 3-6	

Selection of Subjects

There were 3 junior high schools randomly selected by stratification sampling method from Kaohsiung. There were two seventh grade classes randomly selected from each selected school as subjects to have the paper-pencil instrument. There were two senior high schools randomly selected by the stratification sampling method. There was one grade ten class randomly selected as the subject to have the paper-pencil instrument. After grading the paper-pencil instrument, there were 58 seventh graders and 37 tenth graders randomly selected by the stratification sampling method as the subjects for the interview instrument. The stratification for the seventh graders depended on the answer of question 4 in the paper-pencil instrument, for the 10th graders depended on the answer of question 1. The distribution of these subject students for the interview instrument were listed in table 2 and table 3.

Table 2 Subjects of the seventh graders for the interview instrument

School name	class	Right answer	Half right answer	Wrong answer	Total
Ming-chu	1	4 (13)	3 (10)	3 (30)	10 (53)
	2	3 (5)	3 (8)	4 (39)	10 (52)
Yu-chon	3	3 (11)	3 (12)	3 (24)	9 (47)
	4	4 (8)	3 (7)	3 (32)	10 (47)
Nan-Je	5	4 (15)	3 (14)	3 (25)	10 (54)
	6	3 (9)	3 (23)	3 (24)	9 (56)
Total		21 (61)	18 (74)	19 (174)	58(309)

Table 3 Subjects of the tenth graders for the interview instrument

School name	Class	Right answer	Wrong answer	Total
Kaohsiung Girl High	7	6 (14)	3 (37)	9 (51)
	8	6 (35)	3 (17)	9 (52)
Ju-Yu High	9	6 (8)	3 (34)	9 (42)
	10	7 (13)	3 (32)	10 (45)
Total		25 (70)	12 (120)	37 (190)

RESULTS

Recognition of Homologous Chromosomes

According to interview results, within 58 seventh graders, only 16 of them had right conception related to the recognition of homologous chromosomes. There were 20 of 37 tenth graders had the right conception. The other students did not know the answer or had misconceptions. There were four types of misconceptions:

- type 1, Homologous chromosomes were the pair of sticks which were neither the same color nor the same length.
- type 2, Homologous chromosomes were the pair of sticks which were the same color.
- type 3, Homologous chromosomes were the pair of sticks which were either the same color or the same length.
- type 4, Homologous chromosomes were the pair of sticks which were not the same length.

The results of interview students were listed in the table 4.

Table 4 The distribution of results of interviewed students related to the recognition of homologous chromosomes

	right	type 1 error	type 2 error	type 3 error	type 4 error	did not know
class 1	3	1	4	0	2	0
class 2	3	3	1	2	0	1
class 3	2	2	2	2	1	0
class 4	4	3	0	1	0	2
class 5	3	1	0	3	2	1
class 6	1	4	1	1	1	1
Total(58)	16	14	8	9	6	5
class 7	6	0	1	2	0	0
class 8	7	0	2	0	0	0
class 9	1	1	4	2	0	1
class 10	6	0	2	1	0	1
Total(37)	20	1	9	5	0	2

Process of Meiosis

There were 8 students of the 58 interviewed seventh graders, and 13 students of the 37 interviewed tenth graders, who had the right conception. The other 50 seventh graders and 24 tenth graders did not know or had misconceptions.

There were five types of misconceptions:

type 1, Replication was after the first cell division.

type 2, There was no replication.

type 3, There was no synapsis.

type 4, During the first division, one cell got all the chromosomes, the other cell got all the replicated chromosomes.

type 5, When duplication, only paid attention on the length of chromosomes not the color.

The distribution of types of answers are listed in table 5.

Table 5 The distribution of answers related to the process of meiosis

	right answer	type1 error	type2 error	type3 error	type4 error	type5 error	did'nt know
class1	0	2	2	4	0	1	1
class2	0	2	4	4	0	0	0
class3	2	1	2	4	0	0	0
class4	3	1	2	3	1	0	0
class5	2	5	2	1	0	0	0
class6	1	2	3	1	0	0	2
Total(58)	8	13	15	17	1	1	3
class7	2	2	2	2	1	0	0
class8	5	2	1	1	0	0	0
class9	1	3	5	0	0	0	0
class10	5	1	0	3	0	0	1
Total(37)	13	8	8	6	1	0	1

Relationships between Genes, Chromosomes and Traits

Within the 58 interviewed seventh graders, 43 knew that usually the trait was controlled by a pair of genes, 40 of the knew the express of genotype, and 10 of them that the pair of genes for the same trait were on the same loci of the homologous chromosomes. Within the 37 interviewed tenth graders, 36 of them knew that usually the trait was controlled by a pair of genes and also knew the expression of genotype, but only 16 of them really knew that the pair of genes for the same trait were at the same loci of the homologous chromosomes. The misconceptions of the pair of genes for the same trait on the homologous chromosomes were: dominant allele should be the longer chromosomes, recessive allele should be the shorter chromosomes, the alleles should be the same chromosome, the pair of genes for the same trait should not be the same loci on the homologous chromosomes. The distribution of answers is listed in table 6.

Table 6 The distribution of answers related to the pair of genes for the same trait on the same loci of the homologous chromosomes

class	right	partial right	did not know
1	1		10
2	0		10
3	2		7
4	3		7
5	4		6
6	1		8
Total(58)	10		48
7	7	1	1
8	3	1	5
9	2	2	5
10	4	4	2
Total(37)	16	8	13

DISCUSSION AND CONCLUSION

The results of this study indicate that there is learning difficulty for high school students to learn genetics. There is only 28% of the interviewed seventh graders, and 54% of the interviewed tenth graders can recognize the homologous chromosomes. If the student who can not recognize the homologous chromosomes, how can he understand the process of meiosis? Just as the results of this study indicate that only 14% of the interviewed seventh graders, and 35% of the interviewed tenth graders, who can describe the process of meiosis correctly. There is only 17% of the interviewed seventh graders, and 43% of the interviewed tenth graders can understand the relationships between genes, chromosomes and traits.

In this study that the interviewed students were stratified according to the answer of question 1 or question 4 of the paper-pencil achievement test. Question one is related to the inheritance of two traits controlled by two pairs of genes. Question four is related to the inheritance of a trait controlled by a pair of genes. If student who can get the right answer, that means he is high for achievement test. When we analysis these right answer students, we find that only 28% of the seventh graders, and 54% of the tenth graders can recognize the homologous chromosomes; only 14% of the seventh graders, and 35% of the tenth graders can describe the process of meiosis correctly;

and only 17% of the seventh graders and 43% of the tenth graders can understand the relationships between genes, chromosomes, and traits. These results can confirm other researchers' findings (Stewart, 1982) that students have high achievement test scores do not mean that they have right conceptions on genetics learning.

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