An Analysis of the Concepts that Should be Taught to Achieve Class Objectives of Genetics Unit in Biology

Soo-min Lim · Jeong-a Kim[1] · Jong-kyung Sonn · Jae-Hoon Jeong[2] · Young-shin Kim · Ha-young Song[3]*

Kyungpook National University · Daegu High School[1] · Dalsung Elementary school[2] · Seobu High School[3]

Abstract: The researchers who are studying biology and teachers who are teaching biology think that the genetics-related concepts are highly significant than other concepts in biology. With such background, researches on the identification of major concepts have been under way to guide in biology class. Minimal research has been carried out, however, on what concepts should be taught to achieve the specific objectives of the class in relation to the unit of genetics in middle and high school. Accordingly this study was designed to determine the concepts of genetics that should be taught to achieve the objectives of the genetics unit in secondary school. For this purpose 5 instructional objectives of the genetics unit on the 9th grade and 4 instructional objectives of Biology Ⅰ were selected and the concepts that were taught to achieve class objectives. The survey was conducted among 114 science teachers from middle schools and 85 biology teachers from high schools. The results indicated that 9.1 and 10.2 concepts on average were taught in the 9th grade and in Biology Ⅰ respectively. Moreover statistical difference in the number of concepts that were taught according to the teachers' teaching experiences appeared among the middle school teachers ($p<.05$). But such statistical difference did not appear among the high school teachers ($p>.05$). Furthermore the concepts for the 9th grade consist of the basic genetics concepts although Biology Ⅰ concepts were integrated and advanced contents for same concepts. Thus this finding suggests that concepts of genetics units to be taught in middle and high school were in linkage.

Key words: class objectives, biology teacher, teaching concepts, genetics unit

Ⅰ. Introduction

As 21st century changes into an state-of-the-art information era science and technology leads the changes in our daily lives than ever before (Min and Chung, 1997). Since modern science is much related to ethical, social, political and economic realities scientific knowledge has become universal. So it is not needed for particular groups or every individuals in the society (Choi and Cho, 2000). As such demand today's science education should develop the students' capacity to evaluate scientific information or evidence. To supply this need it is important to help the students correctly understand the related scientific concepts (Lewis and Wood-Robinson, 2000).

According to the study conducted by Finley *et al*(1982) biology scholars and teachers believe that genetics concepts are very important among biology concepts. This coincides with the results of other researches conducted in other countries (Hackling and Treagust, 1984; Johnstone and Mahmoud, 1980; Taylor, 1988; Tolman, 1982). In particular based on the finding of study by Finley *et al*(1982) it was found the following genetics concepts are difficult but important: cell division-meiosis, Mendelism and chromosome theory. Also in South Korea 58 % of students said that the unit of life continuity was difficult to understand in biology(Kim, 1994; Kim and Chung, 1995). The reason why there exists highly dependence on genetics concepts compared with the concepts in other areas and the lack of understanding of the basic genetics concepts will impede learning in next level (Song *et al.*, 1991). Accordingly it seems that the teaching of genetics concepts plays a critical role in enhancing understanding of

*Corresponding author: Ha-young Song(cacida@hanmail.net)
**Received on 23 September 2009, Accepted on 26 October 2009

genetics unit (Kim *et al.*, 2006).

In 7th science curriculum the concepts related to genetics are presented on reproduction and evolution unit in 9th grade science in the commencement. This concepts are continued to reproduction unit of 10th grade Science and to genetics unit of Biology Ⅰ and to life continuity unit of Biology Ⅱ. In reproduction and development unit of 9th grade students learn that living things grow and thrive through cell division concept and many other related concepts. And for clear understanding homologous chromosome concept they also need to know the difference between the concepts of somatic cell division and of meiosis. When students study genetics and evolution unit they learn allele unit through Mendelism and genetics concepts. In addition 10th grade students should understand the structure of reproduction organ and forming reproduction cell concept respectively. Also on genetics unit of Biology Ⅰ it is important for students to know about the concepts of genetics trait and gene. At last in Biology Ⅱ the concept of the cell division, cell cycle and DNA change is given(Ministry of Education of Korea, 1997). Out of the system of concepts related to genetics in 7th science education curriculum by grade this conclusion was given. In the present middle and high school biology curriculum of Korea too many concepts are presented in limited hours (Park, 1993). Thus it makes more difficult for the students to learn genetics unit. Accordingly research on the identification of the critical concepts that should be learned during a limited class hour was carried out (Min and Chung, 1997; Cho, 1985). Cho (1985) investigated the university professors' and teachers' recognition of the basic concepts that should be taught in high school Biology. And Yoon (2009) investigated the biology concepts that should be taught in elementary, middle and high school. Moreover Lee (2008) investigated the background concepts that the students should know before learning the genetics concepts. Such researches, however, failed to find out the concepts that should be taught to achieve the specific class objectives in the genetics unit.

Besides the main concepts of the curriculum should be connected with one another between class hours, units and grades (AAAS, 2001,2006). Since there was insufficient consideration of linking the concepts to be taught this will increase the discontinuity among what is taught. Thus it can leads to the waste of learning time. In addition this will decrease the intellectual curiosity or adversely affect the creative and logical thinking abilities of the students. It may serve as a stumbling block to advancing into the next level of learning (Kook and Kim, 2004; Song *et al.*, 1991).

Therefore there is the need to analyze the concepts that should be taught to achieve the class objectives of genetics units. In this respect this study investigates what genetics concepts should be taught to achieve the class objectives of genetics unit of 9th grade in middle school and Biology Ⅰ in high school. Finally the finding of this study will help identify the linkage between the concepts that are to be taught to achieve the class objectives of genetics units in middle and high school.

Ⅱ. Methods and Procedure

1. Subjects

To find out the concepts that are to be taught by the teachers to achieve the class objectives of the genetics units in middle and high school the survey of 114 middle school science teachers and of 85 high school biology teachers was conducted. There were 34 middle school teachers with 5 years teaching experience or less, 27 with 6–10 years , 22 with 11–15 years, 17 with 16–20 years and 14 with 21 years or more. In case of the high school teachers, 20 with 5 years or less, 32 with 6–10 years, 19 with 11–15 years, 6 with 16–20 years and 8 with 21 years or more.

2. Testing tool

To investigate what genetic concepts should be taught to achieve the class objectives of the genetics units in middle and high school the class objectives of the genetics units were sampled. Further the class objectives of the genetics units suggested in the 7th education curriculum , of the 5 9th grade science textbooks and of 5 high school Biology I textbooks were analyzed. Through this process 5 middle school and 4 high school science objectives were chosen.

The open-type survey prequestionnaire which was made consisted of a description of the contents to be taught to achieve the class objectives and of pictures of what have to be taught after presenting the class objectives of the genetics units. Such prequestionnaires were e-mailed to 6 middle school and 5 high school teachers to extract the concepts to be taught to achieve the corresponding objectives. The concepts that were sampled for each objective are shown in ⟨Table 1⟩.

The main questionnaires were designed based on the concepts selected through the prequestionnaires driven from the selected concepts , which were arranged in Korean alphabetic order. The main questionnaires consisted of 5 items for middle school and 4 for high school. All the concepts that are to be taught to achieve each class objective were selected after featuring their pictures. To check the validity of the middle-school-use questionnaire 2 professors majoring in genetics and 3 middle school science teachers were consulted via the prequestionnaire. For the high-school-use questionnaire 2 professors majoring in genetics and 2 high school biology teachers were consulted also via the prequestionnaire. The degree of validity for the middle-school-use questionnaire was .95 while that for the high-school-use questionnaire was .92.

3. Data collection and analysis method

The total of 130 copies of the middle-school-use questionnaire and 110 copies of the high-school-use questionnaire were distributed via e-mail and post along with a letter indicating the purpose of the study and the method of answering the questionnaire. The total of 114(87.7%) accomplished middle-school-use questionnaires and 85(77.3%) accomplished high-school-use questionnaires were collected at last.

The numbers of teachers who selected certain concepts to be taught to achieve each class objective were then determined. Among the concepts that should be taught to achieve certain class objectives those that were selected by more

Table 1

Concepts Sampled in accordance with the Class Objectives of the Middle and High School Genetics Units

Level	Class Objective	No.
Middle School	1. To be able to explain the characteristics of and differences between somatic cell division and meiosis	29
	2. To be able to explain Mendelism	24
	3. To be able to explain the difference between intermediary inheridity and Mendelism	6
	4. To be able to explain how to study human inheritance	9
	5. To be able to give examples of inherited human traits	14
High School	1. To be able to explain the fact that genes exist in the chromosomes	19
	2. To be able to explain the different ways of studying human inheritance	25
	3. To be able to give examples of inherited human traits	17
	4. To be able to explain the causes and kinds of hereditary diseases	19

than 50% of the respondents were identified. For data statistics handling SPSS 14.0K for Windows was used. To identify the statistical difference between the concepts to be taught according to the teachers' experience x^2 verification was carried out.

Ⅲ. Results

1. 9th grade genetics units

(1) "To be able to explain the characteristics of and differences between somatic cell division and meiosis" class objective

〈Table 2〉 shows the concepts that should be taught to achieve the class objective related to the characteristics and differences between somatic cell division and meiosis.

Apart from the concepts in the questionnaires 4 teachers mentioned change in the number of chromosomes, change in the amount of DNA, the number of daughter cells and equatorial plate. More than 50% of the respondent teachers selected the following concepts that they believe should be taught to achieve the class objective: bivalent chromosome, somatic cell division, the number of division, interphase, prophase, metaphase, anaphase, telophase, heterotypical division(meiosis Ⅰ), homotypical division(meiosis Ⅱ), the result of division, daughter cell, the place of division, mother cell, homologous chromosome, cytokinesis and nuclear fission.

In the meantime the study also investigated whether there is a relationship among concepts that should be taught to achieve the class objective by teachers' teaching experiences. The concept of bivalent chromosome topped the list of the concepts that should be taught to achieve the class objective. It is explained by the fact that 100% of the teachers with 15 years or less and 93% of those with 16 years or more selected it. 91-94% of the teachers with 5 years or less selected the number of division, prophase, metaphase, telophase, somatic cell division, anaphase and interphase as the concepts. Among the teachers with 6-10 years 70-92% selected the concepts and 64-71% of those with 21 years or more selected them.

As for the concepts with more than 50% response frequencies owing to the teachers' teaching experiences as followings: bivalent chromosome, somatic cell division, the number of division, interphase, prophase, metaphase, anaphase, telophase, heterotypical division(meiosis Ⅰ), homotypical division(meiosis Ⅱ), the result of division, daughter cell, the place of division, mother cell, homologous chromosome, cytokinesis and nuclear fission. x^2 verification was conducted to see if there is a difference in the number of concepts that the teachers believe should be taught to achieve the class objective by their teaching experiences It appeared that there was a statistical difference ($p<.05$, $x^2=25.135$).

(2) "To be able to explain Mendelism" class objective

〈Table 3〉 indicates the results of the analysis of the concepts that should be taught to achieve the class objectives related to Mendelism.

In the questionnaires 2 teachers cited acquired characteristics, kinds of F_1's gametocyte, F_1's gametocyte ratio and F_2's phenotypic ratio, which were not categorized.

The concepts that should be taught to achieve the class objective were law of dominance, law of independence, law of segregation, dominance, recessive, second filial generation, first filial generation, self-pollination, allelomorphic character, pure breeding, phenotype, genotype, and hybrid.

The concepts of law of dominance, law of independence and law of segregation which had the highest response frequencies were selected by 97.1% of the teachers with 5 years or less, by 100% of the teachers with 6-10, 16-20 years and by 95.5% of the teachers with 11-15 years. Among those with 21 years or more the concept of law of dominance had the highest response frequency (100%). The concept that had the lowest response

Table 2

Results of the Analysis of the Class Objective Related to Somatic Cell Division and Meiosis (%)

Concept	No. of Teachers	Concept	No. of Teachers	Concept	No. of Teachers
Bivalent chromosome	112(98.2)	The result of division	85(74.6)	Chromosome	51(44.7)
Somatic cell division	99(86.8)	Daughter cell	74(64.9)	DNA replication	51(44.7)
The number of division	98(86.0)	The place of division	72(63.2)	cleavage furrow	45(39.5)
Interphase	92(80.7)	Mother cell	70(61.4)	Cell cycle	40(35.1)
Telophase	88(77.2)	Homologous chromosome	69(60.5)	Chromatid	39(34.2)
Heterotypical division (meiosis I)	88(77.2)	Cytokinesis	64(56.1)	Chromatin thread/ chromonema	39(34.2)
Prophase	88(77.2)	Nuclear fission	57(50.0)	DNA	39(34.2)
Metaphase	88(77.2)	tetrad	54(47.4)	dividing chromosome	29(25.4)
Anaphase	88(77.2)	Spindle fiber	54(47.4)	Ovum	25(21.9)
Homotypical division (meiosis II)	86(75.4)	Centromere	51(44.7)	Sperm	25(21.9)

Table 3

Results of the Analysis of the Class Objective Related to Mendelism (%)

Concept	No. of Teachers	Concept	No. of Teachers	Concept	No. of Teachers
Law of dominance	112(98.2)	Allelomorphic character	71(62.3)	Dihybrid	44(38.6)
Law of independence	111(97.4)	Pure breeding	70(61.4)	Monohybrid	37(32.5)
Law of segregation	111(97.4)	Phenotype	65(57.0)	Parent [P]	28(24.6)
Dominance	92(80.7)	Genotype	63(55.3)	Gamete formation	26(22.8)
Recessive	92(80.7)	Hybrid	59(51.8)	Homologous chromosome	25(21.9)
Second filial generation	88(77.2)	Allele	55(48.2)	Cross-pollination	23(20.2)
First filial generation	87(76.3)	Glossary of principal symbols	47(41.2)	Test cross	22(19.3)
Self-pollination	76 66.7)	Trait	46(40.4)	Gene locus	2 (1.8)

frequency was gene locus with 0% of the teachers with 5 years or less, 11–15 years and 21 years or more selecting it. There was one teacher with 6–10 years and another teacher with 16–20 years who selected such concept, which accounts for 3.7 and 5.9% response frequencies respectively.

The following concepts with more than 50% response frequencies were examined by the teachers' teaching experience: law of dominance, law of independence, law of segregation, dominance, recessive, second filial generation, first filial generation, self-pollination, allelomorphic character, pure breeding, phenotype, genotype and hybrid. Also x^2 verification is done to identify if there is a difference in the number of concepts by their teaching experience. It seemed that there was statistical difference ($p<.05$, $x^2=11.231$).

(3) "To be able to explain the difference between intermediary inheridity and Mendelism" class objective

〈Table 4〉 represents the results of the analysis of the 6 concepts that should be taught to achieve the class objective related to the difference between intermediary inheridity and Mendelism.

In particular in the questionnaire 3 teachers said genotype of hybrid and genotype ratio as concepts that they believe should be taught to achieve the class objective.

High percentage of the respondent teachers selected the following concepts as those that they believe should be taught to achieve the class objective: intermediary inheridity, incomplete dominance, phenotype of hybrid, intermediary trait and phenotypic ratio of hybrid.

In the event of the concepts with more than 50% response frequencies according to the teachers' teaching experience were like this: intermediary inheridity, incomplete dominance, phenotype of hybrid, intermediary trait and phenotypic ratio of hybrid. To survey if there is a difference in the number of concepts by their teaching experience, x^2 verification's result showed there was statistical difference ($p<.05$, $x^2=12.160$).

(4) "To be able to explain how to study human inheritance" class objective

〈Table 5〉 is the results of the analysis of the concepts that should be taught to achieve the class objective related to ways of studying human inheritance.

The following concepts as those that should be taught to achieve the class objective were selected: genogram analysis, how to study human inheritance and twin method.

The concept of genogram analysis was chosen by 97.1% of the teachers with 5 years or less followed by 96.3% of the teachers with 6-10 years, 100% of the teachers with 11-15 years, 94.1% of the teachers with 16-20 years and 92.9% of the teachers with 21 years or more. The concept that had the lowest response frequency was blood group inheritance, which was selected by 29.4% of the teachers with 5 years or less. And among the teachers with 6-10 and 11-15 years 29.6 and 31.8% of them, chose amniocentesis and blood group inheritance.

The concepts with more than 50% response frequencies according to the teachers' teaching experience were genogram analysis, how to study human inheritance, and twin method. Through x^2 verification to identify if there is a difference in the number of concepts by their teaching experience it is found that there was statistical difference ($p<.05$, $x^2=10.418$).

(5) "To be able to give examples of inherited

Table 4

Results of the Analysis of the Class Objective Related to the Description of the Difference between Intermediary Inheridity and Mendelism (%)

Instructional Concept	No. of Teachers	Instructional Concept	No. of Teachers	Instructional Concept	No. of Teachers
Intermediary inheridity	114(100)	Phenotype of hybrid	71(62.3)	Phenotypic ratio of hybrid	58(50.9)
Incomplete dominance	98(86.0)	Intermediary trait	62(54.4)	Multiple-allele inheritance	13(11.4)

Table 5

Results of the Analysis of the Class Objective Related to the Description of How to Study Human Inheritance (%)

Concept	No. of Teachers	Concept	No. of Teachers	Concept	No. of Teachers
Genogram Analysis	110(96.5)	Statistical survey	63(55.3)	dominant and recessive inheritance relations in taste blindness	52(45.6)
How to study human inheritance	83(72.8)	PTC	56(49.1)	Amniocentesis	39(34.2)
Twin method	76(66.7)	Taste blindness	56(49.1)	Blood group inheritance	34(29.8)

Table 6

Results of the Analysis of the Class Objective Related to Examples of Inherited Human Traits (%)

l Concept	No. of Teachers	Concept	No. of Teachers	Concept	No. of Teachers
Tongue rolling	108(94.7)	Taste blindness	62(54.4)	Lethal inheritance	33(28.9)
Earlobes inheritance	106(93.0)	Hemophilia	61(53.5)	Eye color	23(20.2)
Blindness	101(88.6)	Sex-linked inheritance	58(50.9)	Incomplete dominance	13(11.4)
Double eyelid	88(77.2)	Multiple-allele inheritance	51(44.7)	Fingerprint	7(6.1)
Carrier	76(66.7)	Hair inheritance	47(41.2)		

human traits" class objective

⟨Table 6⟩ indicates the results of the analysis of the concepts that should be taught to achieve the class objective related to the examples of inherited human traits.

4 teachers presented in the questionnaires the concepts of double-jointed thumb, simian-like forehead and height as concepts that they believe should be taught to achieve the class objective.

Most of the respondent teachers chose the following concepts as those that they believe should be taught to achieve the class objective: tongue rolling, earlobes inheritance, blindness, double eyelid, carrier, taste blindness, hemophilia and sex-linked inheritance.

The concept that had the highest response frequency among the teachers with 5 years or less was earlobes inheritance (100%). As for the teachers with 6-10 or 15-20 years and those with 21 years or more, 96.3, 94.1, and 92.9% of them chose the concepts of tongue rolling and blindness. Among those with 11-15 years. In addition 90.9% chose the concept of blindness.

The concepts with more than 50% response frequencies according to the teachers' teaching experiences were as followings: tongue rolling, earlobes inheritance, blindness, double eyelid, carrier, taste blindness, hemophilia and sex-linked inheritance. x^2 verification to see if there is a difference in the number of concepts that the teachers believe should be taught to achieve the class objective according to their teaching experience were conducted. There was statistical difference ($p<.05$, x^2=15.897).

2. The genetics unit of high School Biology I

(1) "To be able to explain the fact that genes exist in chromosomes" class objective

〈Table 7〉 shows the results of the analysis of the concepts that should be taught to achieve the class objective related to the fact that genes exist in chromosomes.

All the teachers with 16-20 years selected the concepts of chromosome theory, chromosome-gene relations, and Mendel's hypothesis. The rest of the teachers selected the concept of chromosome theory. The concept that had the lowest response frequency was bisexual reproduction with only 10% of the respondents choosing it. It had 0% response frequency among the rest of the teachers.

The concepts with more than 50% response frequencies by the teachers' teaching experience were chromosome theory, chromosome- gene relations, Mendel's hypothesis, theory of gene, linkage, and allele. Following an x^2 verification to see if there is a difference in the number of concepts that the teachers believe should be taught to achieve the class objective according to their teaching experience, it appeared that there was no statistical difference ($p > .05$, $x^2=5.884$).

(2) "To be able to explain how to study human inheritance" class objective

〈Table 8〉 is the results of the analysis of the concepts that should be taught to achieve the class objective related to how to study human inheritance.

Most of the respondent teachers chose the following concepts as those that they believe should be taught in class to achieve the class objective: genogram analysis, karyotype analysis, the study of twins, difficulty of human inheritance, examples of human inheritance, statistical survey and identical twins. In particular as genogram analysis was chosen by 84 out of the 85 teachers, it could be said that this concept to be taught by most of the teachers.

According to teaching experience the concept that had the highest response frequency among the teachers with 5 years or less and 6-10 years was genogram analysis, those with 11-15 years selected genogram analysis and karyotype analysis and those with 16-20 years selected the concepts of genogram analysis and the study of twins and those with 21 years or more selected the concepts of genogram analysis and identical twins.

Next concepts were chosen by more than 50% according to the teachers' teaching experiences: genogram analysis, karyotype analysis, the study of twins, difficulty of human inheritance, examples of human inheritance, statistical survey, and identical twins. x^2 verification was followed to

Table 7

Results of the Analysis of the Class Objective Related to the Fact that Genes Exist in the Chromosomes (%)

Concept	No. of Teachers	Concept	No. of Teachers	Concept	No. of Teachers
Chromosome theory	82(96.5)	Homologous chromosome	37(43.5)	Gamete formation	29(34.1)
Chromosome- gene relations	70(82.4)	Linkage inheritance	36(42.4)	Chromosome	23(27.1)
Mendel' s hypothesis	62(72.9)	Repulsion linkage	35(41.2)	Gene	17(20.0)
Theory of gene	59(69.4)	Linkage group	35(41.2)	Nuclear phases	11(12.9)
Linkage	52(61.2)	Coupling linkage	34(40.0)	Bisexual reproduction	2(2.4)
Allele	51(60.0)	Mendelism	29(34.1)		

see if there is a difference in the number of concepts according to their teaching experience, which was no statistical difference (p>.05, x^2 =5.871).

(3) "To be able to give examples of inherited human traits" class objective

⟨Table 9⟩ represents the results of the analysis of the concepts that should be taught to achieve the class objective related to the examples of inherited human traits.

Plenty of the respondent teachers chose the following concepts as those that they believe must be taught to achieve the class objective:

Table 8

Results of the Analysis of the Class Objective Related to the Description of How to Study Human Inheritance (%)

Concept	No. of Teachers	Concept	No. of Teachers	Concept	No. of Teachers
Genogram analysis	84(98.8)	Recessive inheritance	26(30.6)	Sex determination	14(16.5)
Karyotype analysis	72(84.7)	Dominant inheritance	25(29.4)	Chromosome- gene relations	13(15.3)
The study of twins	69(81.2)	DNA analysis	23(27.1)	Fertilization	11(12.9)
Difficulty of human inheritance	66(77.6)	Sex-linked inheritance	22(25.9)	Chromatid	11(12.9)
Examples of human inheritance	64(75.3)	Homologous chromosome	22(25.9)	Gamete formation	9(10.6)
Statistical survey	54(63.5)	Chromosome	21(24.7)	Development	9(10.6)
Identical twins	53(62.4)	Nuclear phases	19(22.4)	Linked genes	5(5.9)
Fraternal twins	47(55.3)	Sex chromosomal inheritance	16(18.8)		
Autosomal inheritance	33(38.8)	Hereditary diseases	15(17.6)		

Table 9

Results of the Analysis of the Class Objective Related to the Example of Inherited Human Traits (%)

Concept	No. of Teachers	Concept	No. of Teachers	Concept	No. of Teachers
Multifactorial inheritance	85(100)	Sex-chromosome-linked inheritance	38(44.7)	Dominance	26(30.6)
Single-factor inheritance	80(94.1)	Allelomorphic character	37(43.5)	Recession	26(30.6)
Multiple-allele inheritance	77(90.6)	Phenotype	32(37.6)	Mendelism	20(23.5)
Sex-linked inheritance	71(83.5)	Genotype	32(37.6)	Autosome	20(23.5)
Sex-limited inheritance	71(83.5)	Genetic character	32(37.6)	Sex chromosome	19(22.4)
Autosomal inheritance	56(65.9)	Autosome-linked inheritance	28(32.9)		

multifactorial inheritance, single-factor inheritance, multiple-allele inheritance, sex-linked inheritance, sex-limited inheritance and autosomal inheritance.

By teaching experience the concept that had the highest response frequency among the teachers with 5 years or less, and among those with 6-10 years and 21 years or more was multifactorial inheritance. The teachers with 11-15 years selected the concepts of multifactorial inheritance, single-factor inheritance, sex-linked inheritance, sex-limited inheritance and those with 16-20 years selected the concepts of multifactorial inheritance and multiple-allele inheritance.

And the concepts with more than 50% response frequencies according to the teacher's years of teaching experience were multifactorial inheritance, single-factor inheritance, multiple-allele inheritance, sex-linked inheritance, sex-limited inheritance and autosomal inheritance. Following x^2 verification to see if there is a difference in the number of concepts that the teachers believe should be taught to achieve the class objective according to their teaching experience showed that there was no statistical difference ($p>.05$, $x^2=8.166$).

(4) "To be able to explain the causes and kinds of hereditary diseases" class objective

⟨Table 10⟩ is the results of the analysis of the 19 concepts that should be taught to achieve the class objective related to the causes and kinds of hereditary diseases.

To achieve the class objective the following concepts are suggested to be taught in class: nondisjunction, chromosome aberration(deletion, inversion, translocation, duplication), chromosome mutation, Klinefelter's syndrome, chromosome aberration(aneuploidy, polyploidy), gene mutation, Down's syndrome, cri-du-chat syndrome, Turner's syndrome, sickle cell anaemia, mutation, DNA sequence aberration, Edward syndrome, phenylketonuria, albinism and spindle aberration in meiosis.

According to teaching experience the concepts that had the highest response frequencies among the teachers with 5 years or less were nondisjunction, chromosome aberration(deletion,

Table 10

Results of the Analysis of the Class Objective Related to the Causes and Types of Hereditary Diseases (%)

Concept	No. of Teachers	Concept	No. of Teachers	Concept	No. of Teachers
Nondisjunction	84(98.8)	Cri-du-chat syndrome	74(87.1)	Albinism	50(58.8)
Chromosome aberration (deletion, inversion, translocation, duplication)	84(98.8)	Turner' s syndrome	74(87.1)	Spindle aberration in meiosis	43(50.6)
Chromosome mutation	84(98.8)	Sickle cell anaemia	72(84.7)	Karyotype analysis	42(49.4)
Klinefelter' s syndrome	80(94.1)	Mutation	67(78.8)	The meiosis process	25(29.4)
Chromosome aberration (aneuploidy, polyploidy)	80(94.1)	DNA sequence aberration	60(70.6)	DNA	9(10.6)
Gene mutation	79(92.9)	Edward syndrome	57(67.1)		
Down' s syndrome	76(89.4)	Phenylketonuria	50(58.8)		

inversion, translocation, duplication), chromosome mutation, and chromosome aberration (aneuploidy, polyploidy), those with 6–10 years selected the concepts of nondisjunction and chromosome aberration(deletion, inversion, translocation, duplication), those with 11–15 years selected nondisjunction, chromosome aberration(deletion, inversion, translocation, duplication), chromosome mutation, chromosome aberration (aneuploidy, polyploidy), Klinefelter's syndrome, gene mutation, those with 21 years or more selected chromosome and gene mutation.

More than 50% teachers according to the teachers' teaching experience selected these concepts: nondisjunction, chromosome aberration(deletion, inversion, translocation, duplication), chromosome mutation, Klinefelter's syndrome, chromosome aberration (aneuploidy, polyploidy), gene mutation, Down's syndrome, cri-du-chat syndrome, Turner's syndrome, sickle cell anaemia, mutation, DNA sequence aberration, Edward syndrome, phenylketonuria, albinism and spindle aberration in meiosis. χ^2 verification was followed to see if there is a difference in the number of concepts that the teachers believe should be taught to achieve the class objective according to their teaching experience, which appeared that there was a statistical difference ($p < .05$, $\chi^2=11.788$).

3. Comparison of the genetics concepts to be taught between middle school and high school

⟨Table 11⟩ summarizes the number of concepts that, more than 50% of the respondents said, should be taught according to the class objectives. The middle school teachers cited that an average of 3.6–16.9 concepts should be taught for class objective although the high school teachers indicated that 8.5–14.0 concepts should be taught. The characteristics and differences between somatic cell division and meiosis was selected as the most important topic that should be taught in middle school. However the causes and kinds of hereditary diseases was regarded as the most important topic to be taught in high school.

⟨Table 12⟩ shows the concepts that are being taught in the genetics unit by school level. It appeared that a total of 78 concepts are being taught in the genetics units of middle and high school, with 48 concepts in middle school and 43 in high school. A total of 13 concepts were chosen as common concepts.

Genogram analysis, the study of twins and statistical survey were the concepts that should be taught both in middle and high school to achieve the class objective "To be able to explain the ways of studying human inheritance". Futhermore sex-linked inheritance is the concept that the teachers believe should be taught both in middle and high school to achieve the class objective "To be able to give examples of inherited human traits."

The following concepts are taught to achieve the other class objectives of the genetics units in middle and high school: homologous chromosome, law of dominance, law of independence, law of

Table 11

The Number of recognition about concept to be instructed in the genetics unit of secondary school

middle school				high school			
class objective	maximum No. of concepts	minimum No. of concepts	Average	class objective	maximum No. of concepts	minimum No. of concepts	Average
1	29	1	16.9	1	17	3	8.6
2	24	3	12.9	2	23	4	9.6
3	6	1	3.6	3	17	6	8.5
4	9	1	4.9	4	18	2	14.0
5	13	2	7.4				

Table 12

The comparison of concept to be instructed to achieve the class objective in the genetics unit of secondary school

school level concept	middle school	high school	school level concept	middle school	high school	school level concept	middle school	high school
bivalent chromosome	O		phenotypic ratio of hybrid	O		linkage		O
somatic cell division	O		How to study human inheritance	O		nondisjunction		O
the number of division	O		tongue rolling	O		Chromosome aberration (deletion, inversion, translocation, Duplication)		O
interphase	O		ear lobes inheritance	O		chromosome mutation		O
prophase	O		blindness	O		Klinefelter's syndrome		O
metaphase	O		double eyelid	O		Chromosome aberration(aneuploidy, polyploidy)		O
anaphase	O		carrier	O		gene mutation		O
telophase	O		taste blindness	O		Down's syndrome		O
heterotypical division	O		hemophilia	O		cri-du-chat syndrome		O
homotypical division	O		homologous chromosome	O	O	Turner's syndrome		O
the result of division	O		law of dominance	O	O	sickle cell anaemia		O
daughter cell	O		law of independence	O	O	mutation		O
the place of division	O		law of segregation	O	O	DNA sequence aberration		O
mother cell	O		dominance	O	O	edward syndrome		O
cytikinesis	O		recessive	O	O	phenylketonuria		O
nuclear fission	O		allelomorphic character	O	O	albinism		O
first filial generation	O		allele	O	O	karyotype analysis		O
second filial generation	O		genotype	O	O	difficulty in human inheritance		O
self-pollination	O		genogram analysis	O	O	example in human inheritance		O
pure-breeding	O		twin method	O	O	identical twin		O
phenotype	O		statistical survey	O	O	fraternal twin		O
hybrid	O		sex-linked inheritance	O	O	multifactorial inheritance		O
intermediary inheridity	O		chromosome theory		O	single-factor inheritance		O
incomplete dominance	O		chromosome - gene relations		O	multiple allele inheritance		O
phenotype of hybrid	O		Medel's hypothesis		O	sex-limited inheritance		O
intermediarytrait	O		theory of gene		O	autosomal inheritance		O

segregation, dominance, recessive, allelomorphic character, allele, genotype, gamete formation, chromosome and DNA.

Ⅳ. Discussion

Until now this study surveyed what biology concepts should be taught to achieve the class objectives of middle and high school by class objectives and teaching experiences.

1. 9th grade genetics unit

As for "To be able to explain the characteristics and differences between somatic cell division and meiosis" class objective, the most selected concept by teachers was bivalent chromosome(98.2%) and the least selected concept was ovum(21.9%) and sperm concept(21.9%). The reason why it seems that bivalent chromosome concept makes a feature the process and characteristics of cell division. But it is thought that sperm and ovum concepts are more appropriate for teaching the class objective "The structure and function of reproduction organ" than this objective. Dividing chromosome concept(25.4%) was also low percent because it is not generally represented on most textbooks and exercises book. Another reason is dividing chromosome concept made students had difficulties because of terminology in the textbooks(Hwang and Lee, 2000). Min and Chung (1997) surveyed on middle students' and biology teachers' cognition of biology concept in the unit the continuity of life. In that study the concept that had highest importance by teachers was somatic cell division and meiosis concepts and lowest importance was daughter cell concept regarding cell division subunit, which was similar finding in comparison with this study.

In case of "To be able to explain Mendelism" class objective, the concept that ranks high level were law of dominance(98.2%), law of independence(97.4%), law of segregation(97.4%). The reason why these concepts were selected is that those are basic concepts for understanding Mendelism. Meanwhile the least chosen gene locus(1.8%) and test cross concepts(19.3%) are proper for Biology Ⅱ in high school. According to Min and Chung (1997) for the subunit of genetics and evolution on unit the continuity of life in middle school the law of dominance concept was the most selected and PTC concept was the least. It is said that the law of dominance concept is generally considered as important concept in general.

As for "To be able to explain the difference between intermediary inheridity and Mendelism" class objective, Intermediary inheridity concept(100%) was on the top and multiple-allele inheritance concept(11.4%) hit the bottom. The concept of intermediary inheridity is driven from obscurity in Mendelism so it is contrary to Mendelism concept which was learned before. In addition the multiple-allele inheritance concept should be taught on class objective of "To be able to explain how to study human inheritance".

Futhermore on "To be able to explain how to study human inheritance" class objective, teachers who were correspondent selected Genogram Analysis concept(96.5%) highly and Blood group inheritance(29.8%) least. Because Genogram Analysis concept is most basic method for studying human inheritance. In case blood group inheritance concept it seems necessary to teach it to achieve the class objective "To be able to give examples of inherited human traits".

Finally for achieving the class objective of "To be able to give examples of inherited human traits", it was found out Tongue rolling(94.7%) and Earlobes inheritance concepts(93%) should be taught importantly. This is why these concepts are represented on most middle school textbook. On the other side fingerprint concept(6.15%) which was the least selected is not general concept to be taught.

2. The genetics unit of high school Biology Ⅰ

To achieve the class objective "To be able to explain the fact that genes exist in chromosomes", the concept of bisexual reproduction(2.4%) should be taught importantly. It seems to be more appropriate to teach to achieve the class objective suggested in the unit of reproduction and development in 9th grade. It is thought that Chromosome theory(96.5%) had highest frequency as it is usually shown on most textbook.

And for teaching "To be able to explain how to study human inheritance" class objective, the most selected concept was Genogram analysis(98.9%). Linked genes(5.9%) which had the lowest response frequency appears to be more appropriate to teach to achieve the class objective "To be able to explain the fact that genes exist in the chromosomes". This class objective is also under the genetics unit of middle school although the number of concepts that are considered important teach appeared to be less in middle school. Also the difference between middle school and high school is as followings. In middle school the teaching focused on genogram analysis, the study of twins and statistical survey. But in high school the focus appeared to be on karyotype analysis, identical twins, fraternal twins and difficulty of human inheritance.

In case of class objective "To be able to give examples of human traits" multifactorial inheritance(100%) concept was the maximum. Moreover it is notable that although 7th science education curriculum does not include Mendelism(23.5%) that concept was chosen by teachers. Since it indicates that Mendelism is also needed for teaching genetics in high school the people who develope next science education curriculum and make textbooks need to concentrate on this finding.

To achieve class objective "To be able to explain the causes and kinds of hereditary diseases", teachers selected Nondisjunction concept(98.8%) which is most considered to be taught. Since it is the direct cause or hereditary disease. While the concept that was least selected was DNA(10.6%), which seems to be appropriate to teach in the genetics unit of Biology Ⅱ.

Therefore the most important suggestion of this study is the concepts that should be taught to achieve the class objective for each class was found. This finding is useful for newly appointed and less experienced biology teachers to design content of the class to teach genetics unit. It is better that they organize the class contents based on the concepts which are highly selected by teachers.

Next in the study analyzed by teaching experience the difference was found among the concepts that the respondent, teachers believe, should be taught to achieve the class objectives of the genetics unit. For middle school teachers it was showed a statistical difference in the number of concepts according to their teaching experience ($p<.05$). Whereas no such statistical difference was seen in high school ($p>.05$). The number of concepts to be represented by the middle school teachers with 11-20 years suggested the least among those teaching than the other grade levels. It is thought that the teachers with many teaching experience have an inclined to recognize same concepts as intergrated things. Moreover on the same class objectives there was a larger variance among the concepts to teach by each teacher. So appropriate measurement tools are required to narrow down the difference in the number of concepts to teach and teachers have to get common concepts through consensus using communication or discussion with other teachers.

As for the average number of concepts taught according to the class objectives 9.1 concepts were suggested in middle school while 10.2 concepts were suggested. It seems to be on the reason that teaching concept is focusing on phenomena in middle school although the concepts that ,teachers believe, should be taught to achieve the class objectives of high school Biology Ⅰ oriented on theory. This fully reflects the sprit of the content formation of the 7th science education curriculum (Ministry of Education of Korea, 1997). This coincides with the results of the study conducted by Sim *et al.* (2003) claiming that the higher the school level had the greater the number of concepts to be taught. And it was reported in the prestudy that students had learning difficulties as there was an increase in the number of concepts in the process of learning biology (Kim and Oh, 1995; Kim, 2005; Park, 1993). It can be said that this study supports these prestudies. Therefore it is desirable to readjust the number of concepts for students to understand them effectively and easily.

V. Conclusion and Suggestion

The purpose of this study was to analyze what biology concepts to be taught to achieve the class objectives of middle and Biology I of high school genetics units. The examination sheet consisted of pictures that correspond to the class objectives of the genetics unit in the 7th science education curriculum. The study examined 5 class objectives for middle school and 4 class objectives for high school. The following conclusions and suggestions were drawn based on the study findings:

(1) It appeared that the number of concepts that should be taught to achieve the class objectives of the genetics unit was larger in high school than in middle school. This is explained that as screw education curriculum is well adjusted the contents are more deepen by Kang and Song(2008). So teachers teaching genetics unit in high school should try to find the best way to teach many concepts effectively for students in class.

(2) Teaching experience is significant factor which has an effect on selecting concept of genetics unit in middle school. However in high school it doesn't have influence. Thus the right reason why this finding was given will be a future research area.

(3) It is said that the genetics units of middle and high school to be taught are in linkage with each other. Among the genetics concepts that should be taught to achieve class objectives, 16 concepts were selected by both middle and high school teachers. It is likely that teachers teach basic concepts in middle school although they teach integrated and advanced concepts for same concept. This is different in comparison with the study that has liaison to the content related genetics unit between middle and high school, was not found by Kang and Song (2008).

Through this survey it was found that there is a need to rearrange the concepts to be taught to effectively achieve the class objectives onsite by identifying what concepts should be taught by the teachers within limited class hour. Furthermore for higher linkage of the class objectives between middle school and high school the list of the concepts that should be taught is needed, which will serve as a basic resource for structuring the renewed educational curriculum and for developing next textbooks.

Reference

American Association for the Advancement of Science(AAAS. 2001). Project 2061 : Atlas of science literacy. Washington, DC.

American Association for the Advancement of Science(AAAS. 2006). Project 2061 : Atlas of science literacy Vol II. Washington, DC.

Cho, Hee-Hyung(1985). Identification and determination of basic concepts necessary for high school biology curriculum. Journal of the Korean Association for Research in Science Education, 5(1), 11-17.

Choi, Kyung-Hee, Cho, Hee-Hyung(2000). The teaching / learning procedures and themes for ethical issues in science. The Korean Journal of Biology Education, 28(4), 408-417.

Finley, F. N., Stewart, J., & Yarroch, W. L. (1982). Teachers' perceptions of important and difficult science content. Science Education, 66(4), 531-538.

Hackling, M. W., &Treagust, D. (1984). Research data necessary for meaningful review of grade ten high school genetics curricula. Journal of Research in Science Teaching, 21(2), 197-209.

Hwang, Sue-Yun, Lee Jin Sung(2000). Suggestions to improve high school students' understanding about meiosis. Journal of Biological Education, 28(4), 342-347.

Johnstone, A. H., &Mahmoud, N. A. (1980).

Isolating topics of high perceived difficulty in school biology. Journal of Biological Education, 14(2), 163-166.

Kang, Youn-Kyung, Song Bang-Ho(2008). Liaison analysis between school grades in genetics of biology textbooks under korean secondary school. Journal of Biological Education, 36(4), 429-443.

Kim, Hye-Won (2005). The preference of high school students to the science subjects. A thesis of master degree in Kyungpook National University.

Kim, Hyun-A, Lee, Dong-Jun, Lee, Joon-Kyu(2006). Analysis of conceptual level and organization on the unit related with continuity of the life in middle school science textbook. The Korean Journal of Biology Education, 34(3), 342-354.

Kim, Won-Sook(1994). The influences of retinoic acid on the formation of axis and somitogenesis in amphibian embryo and development of experiment to teach the animal embryogenesis. Unpublished Doctoral Dissertation. Seoul National University.

Kim, Won-Sook, Chung, Hae-Moon (1995). The survey on the view of high school students' on the studying embryology and the analysis of the textbook for embryology experiment. The Korean Journal of Biology Education, 23(1), 51-62.

Kim, Young-Soo, Oh, Keum-Young(1995). Concept mapping as an instructional strategy for the middle school biology : Student - centered versus teacher - centered concept mapping. The Korean Journal of Biology Education, 23(2), 213-230.

Kook, Dong-Sik, Kim, Hak-Man(2004). An analysis on the conceptual connection of meteorology contents in science courses of elementary, middle and high School. Bulletin of Science Education, 20(1), 1-10.

Lee, Young-Eun(2008). The background concept analysis of genetics domain recognized by high school biology teachers. A thesis of master degree in Kyungpook National University.

Lewis, J., & Wood-Robinson, C. (2000). Genes, chromosomes, cell division and inheritance - Do students see any relationship? International Journal of Science Education, 22(2), 177-195.

Min, Hyo-Jeong, Chung, Young-Lan(1997). A survey on middle school students' and biological teachers' cognition of biological concepts in the unit 'The continuity of life'. Journal of the Korean Association for Research in Science Education, 17(1), 21-29.

Ministry of Education of Korea. (1997). Science curriculum. Seoul: Daehan Printing & Publishing Company.

Park, Jin-Hee(1993). Middle school students' and biology teachers' cognition of difficulty and importance of biological concepts: Digestion, circulation, excretion, and respiration. A thesis of master degree in Seoul National University.

Sim, Gyu-Cheol, Lee, Bu-Yeon, Kim, Hyeon-Seob(2003). Analysis of learning concepts related to metabolism presented in the life filed of science textbooks according to the national common basic curriculum. Journal of the Korean Association for Research in Science Education, 23(6), 627-633.

Song, Soon-Hi, Lee, Young-Ha, Lee, Jong-Rock, Kim, Sung-Won, Kang, Soon-Hee, Park, Jong-Yoon, Kang, Soon-Ja, Kim, Kyu-Han, Yoo, Kye-Hwa(1991). Development and application of an analysis taxonomy for curricular articulation in mathematics and science. Journal of the Korean Association for Research in Science Education, 11(2), 119-131.

Taylor, M. F. (1988). Hands-on activity for mitosis, meiosis and the fundamentals of heredity. The American Biology Teacher, 44(9), 525-527.

Tolman, R. R. (1982). Difficulties in genetics problem solving. The American Biology Teacher, 44(9), 525-527.

Yoon, Jung-Ju(2009). The study on the recognition about biology concepts to be taught in elementary middle and high schools by biology teacher. A thesis of master degree in Kyungpook National University.