# A Study on Effect of Meiosis Background Concepts on the High School Students' Understanding of Meiosis

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**Abstract:** The objectives of this study were to investigate what kind of background concepts is necessary to help that high school students easily understand meiosis and to find out how these background concepts affect students' understanding of meiosis. To achieve these objectives, first this study surveyed meiosis background concepts that high school teachers think. Based on 8 background concepts - nuclear phases, chromosome, mitosis, reproduction, gamete, gene, mother/daughter cell - of previous survey, the questionnaire was made for the 10th(724) and 11th(862) grade students and then was analyzed for the effect of meiosis background concepts on the high school students' understanding of meiosis. Results of the analysis revealed that the influential background concepts are as follow; cell cycle, chromosome in the advanced level, mother/daughter cell, mitosis, chromosome, nuclear phases in the intermediate level, mother/daughter cell, nuclear phases, gene in the low level. And the achievement according to item types was differed not by meiosis achievement, but by each background concepts.

Key words: meiosis, background concepts, understanding meiosis, understanding of meiosis, heredity

## Ⅰ. Introduction

The concept is a important tool that is used not only to facilitate comprehensive understanding of certain knowledge system but also to adjust the amount of knowledge, which is appropriate for aim of education. The concepts have the logic and meaning of their own, thus influence concept stabilization or change (Cho, 2002). Biology is a study that explores the phenomena of life, structure and function of organism, which has specific and conceptual characteristics. Biological concepts are not only helper of understanding whole structure of knowledge for biology, but also mediator of adjusting amount of biological knowledges(Cho, 1985). But biological concepts were restricted to theoretical ones qualititavely (Cho, 2002), therefore, students think that biology is very difficult subject because they face a great number of concepts and terminologies, and then they feel that they are compelled to thoughtlessly memorize all those concepts (Banet & Ayuso, 2000; Kim, 2005). Moreover, students find it difficult to learn biology because it mainly consists of terminology-centered concepts and they have to form current concepts without prior concepts (Kim *et al.*, 2006; Park, 1993)

In biology, concepts which are related to heredity are important because they are related to other units as cell, reproduction and development and evolution. So teachers of biology should teach concepts of heredity by considering above all (Kim, 2008; Kim *et al.*, 2002; Finley *et al.*, 1982). Even in the unit of heredity, concepts are relevant between one sub-topic and another sub-topic (Kim *et al.*, 2006). Furthermore, since these concepts are abstract and complex, which are closely linked with other concepts such as cell, reproduction and development, students cannot understand them or have many misconceptions (Kim *et al.*, 2001; Chung and Kim, 2002; Duncan *et al.*, 2009; Knippels *et al.*, 2005; Michael & Robert, 1987; Lewis & Wood-Robinson, 2000). In particular, meiosis is important the basic concept that helps to accurately understand genetic principles and life continuity of organism including human beings, which breeds through sexual reproduction (Hwang and Lee, 2000).

At present, Korea's science education curriculum is as follows. Cell composition and

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chromosomes, as well as the basic principles of heredity and evolution are taught in middle school, followed by further details of cell division and meiosis in high school. Despite repeated learning, students find it difficult to understand the concepts of cell division, specifically meiosis. Naturally they have many misconceptions (Bae *et al.*, 2007; Dong, 2002; Finley *et al.*, 1982; Hwang and Lee, 2000; Knippels *et al.*, 2005; Mertens & Walker, 1992; Tolman, 1982). Students are not familiar with the definitions of terminologies that related to heredity, as well as they don't comprehend any connections among concepts. Those who fail to understand the connection of heredity-related concepts have a great deal of misconception, and are subject to solve problem based only on simple memorization or calculations (Banet & Ayuso, 2000; Choi and Cho, 1987; Kindfield, 1994; Knippels *et al.*, 2005; Mertens & Walker, 1992; Michael & Robert, 1987; Min *et al.*, 2004; Tolman, 1982).

In forming concepts, however, there is a growing emphasis on the importance of prior knowledge of students, which is related to learning content (Ko *et al.*, 1997; Stuart, 1982; Yenlimez *et al.*, 2006). Prior knowledges of learners have crucial roles to form scientific knowledge (Edens & Potter, 2003; Gijlers & Jong, 2005). Of such prior knowledge, a background knowledge is referred to as a scientific knowledge that students should know, which is connected to what they will learn (Lee, 2008). Background knowledge is not assessed directly, instead, it is the relevant knowledge that students use in understanding certain concept. To understand new concept, it requires the sufficient background knowledge (Chinn & Brewer, 1993). Furthermore, with no certain background knowledge, students cannot understand the logic underlying new learning concept that is directly evaluated (Choi, 2009; Kang *et al.*, 2004). Accordingly, a background knowledge plays an important role in forming a new concept (Chung, 2001; Venville & Treagust, 1998). Background concept, therefore, is referred to as the scientific concept which are composed of the background knowledge (Jeong *et al.*, 2010; Kang *et al.*, 2004).

A simple look into previous research reveals that there was hardly any research on the background concept of meiosis. Accordingly, the objectives of this study is to investigate what kind of background concepts is necessary to help high school students better to understand meiosis, and how much background concepts of meiosis influences the conceptual formation of meiosis. This study specifically focuses on the following issues: (1) to investigate the background concepts necessary for the understanding of the concept of meiosis that is recognized by high school biology teachers and (2) to analyze how background concepts on meiosis affect the understanding of high school students by achievement of meiosis.

## Ⅱ. Design and Methodology

### 1. Sampling

#### Meiosis Examination Sheet: Background concept

To know what kind of background concepts is necessary to facilitate the understanding on the concept of meiosis, 48 high school biology teachers were sampled.

#### Meiosis Examination Sheet: Achievement

To examine how background concept of meiosis affect the understanding of high school students on meiosis, in total 1,586 students nationwide who studied unit in meiosis were surveyed: 724 10th grade students (372 males and 352 females) and 862 11th grade students (564 males and 298 females). They were evenly selected by grade, gender and region, which were metropolitan, small-medium, small cities.

### 2. Questionnaire development.

#### Meiosis Examination Sheet: Background concept

The examination sheet was open-type

questionnaire and was structured to present partial contents with explanation of each concept. It was based on High School Biology Ⅰ and Ⅱ of the 7th education curriculum. We explained the purpose of this study and definition of background concept to 48 high school biology teachers. Teachers were asked to write freely what concepts are necessary to help the understanding of students before they learn certain concept. To see how concepts in heredity are actually taught in class, 3 female teachers out of the surveyed 48 teachers were interviewed after teachers' survey.

### Meiosis Examination Sheet: Achievement

Based on the results of previous survey (background concept of meiosis on high school biology teachers Table 1), the following 8 concepts were selected as necessary background concepts: nuclear phases, chromosomes, mitosis, sexual reproduction-asexual reproduction, reproduction cell, gene, mother cell-daughter cell and cell cycle.

Sexual reproduction and asexual reproduction are considered as 1 concept since they are reciprocally related concepts; in the same reason, mother cell and daughter cell were also treated as 1 single concept, too. The examination sheet to identify the students' achievement on 8 selected background concepts and meiosis, was designed with a total 38 multiple choice questions: 4 questions for each background concept considering knowledge, appreciation and application and 6 questions for meiosis. The validity of 38 questions was gained by 2 experts in biology education and 3 biology teachers, which was rated 85.89%. After modifications the test of reliability was conducted for 4 classes (each 2 classes from the 10th and 11th grades), that was, reliability of Cronbach's .843.

## 3. Data Collection and Analysis

### Meiosis Examination Sheet: Background concept

The meiosis examination sheet for high school biology teachers was distributed to 48 teachers who agreed to participate in the survey through mail and e-mail. After briefly being heard the objective of the study, they were encouraged to write freely, and then the survey sheets were collected. In addition to the teachers' survey, 3 high school biology teachers were interviewed in order to know how background concepts is are taught in real classroom. Through the interview we identified how background concepts suggested by teachers are connected with what their students should learn in real and asked why they suggested such concepts for background concepts. In analyzing the back concepts on meiosis presented by high school biology teachers the concepts were listed on the questionnaire, lined up according to the number of responding teachers in order.

### Meiosis Examination Sheet: Achievement

To examine how background knowledge on meiosis affects the understanding of high school students on meiosis, survey was conducted on 10th and 11th grade students. After the objectives of the study and the testing method were explained to biology teachers from the selected schools, students from that school were then surveyed. To investigate after the meiosis class, the examination sheets were distributed during the first week of December. The actual survey was conducted in first and second weeks of December, and were collected at the end of the same month. The student respondents had 50 minutes to answer the questionnaire. After all the responses were collected and coded, the data was statistically analyzed using SPSS 14.0K for Windows and Microsoft Office Excel 2003.

As for grading, 1 point was given for correct answer and 0 for other cases. After grading, each concept were grouped together to calculate total score, followed by measuring the achievement of 8 background concepts including meiosis. According to the achievement of meiosis, classified by 3 categories: advanced, intermediate and low. The advanced group

includes 5 to 6 correct answers out of 6 questions, the intermediate group has 3 and 4 correct answers, and the low group has 2 or less. After analyzing the achievement of 3 groups related to the 8 background knowledge according to an achievement of meiosis, this study used correlation and multiple regression analyses to examine the effects on achievement of each background knowledge on the understanding of meiosis. Furthermore, this study also found out how background knowledge affects the understanding of meiosis by grade.

## Ⅲ. Results

This study investigated the background concepts of high school biology teachers connected to meiosis and analyzed how background concept of meiosis affects the understanding of meiosis of high school students. For this, students of 10th and 11th grade participated on the survey about meiosis and the 8 background knowledge. The results gained are as follows:

### Analysis by Background concept on Meiosis

The list of background concepts on meiosis varied from 2 to 22 concepts. 72 of concepts were extracted, which is shown in Table 1.

35 out of 48 teachers said that the concept of nuclear phase was the most important concept needed to understand meiosis. Chromosomes gained the second, 25 responded, The third was mitosis with 22 responses, and then sexual reproduction with 21. Other identified concepts were gamete with 18 responses, fertilization 16 and DNA 15.

And then, 3 teachers among 48 teachers were interviewed to see how genetics concepts are actually taught in real classroom. First, the 3 teachers were asked what background knowledge is needed for students before learning

**Table 1**

*Background concept of meiosis by high school biology teachers (N=48)*

| concepts | Number. of teachers | concepts | Number of teachers | concepts | Number of teachers |
|---|---|---|---|---|---|
| nuclear phases | 35 | chromosomes | 25 | mitosis | 22 |
| sexual reproduction | 21 | reproduction cell | 18 | fertilization | 16 |
| DNA | 15 | mother cell | 11 | homologous chromosome | 10 |
| relative amount of DNA | 10 | number of chromosomes | 9 | cell cycle | 8 |
| chromatid | 8 | gene | 7 | chromosome thread | 7 |
| asexual reproduction | 7 | reproduction | 6 | daughter cell | 6 |
| bivalent chromosome | 6 | heredity | 6 | nucleus | 5 |
| somatic cell | 5 | spindle fiber | 5 | nuclear division | 5 |
| cytokinesis | 4 | structure of cell | 4 | cell | 4 |
| centromere | 3 | cell division | 3 | division | 3 |
| centriole | 3 | karyotype | 3 | reproductive organ | 2 |
| structure of reproductive organ | 2 | fertilized ovum | 2 | heterotypic division | 2 |
| genetic information | 2 | replication | 2 | DNA replication | 2 |
| significance of division | 2 | homotypic division | 2 | multicellular organism | 2 |
| meiosis | 2 | Autosome | 1 | | |

meiosis. All the 3 teachers stated nuclear phase first, proposed chromosomes and mitosis. In addition, they also mentioned that the contents of meiosis, which is taught, are process of off-spring reproduction through increase in the number of reproduction cell and as the results of meiosis, the number of chromosomes and DNA's are reduced half. Based on the previous survey, nuclear phase is used to emphasize meaning of meiosis, and it is necessary to explain reduction half of nuclear phases, which is the largest difference from mitosis. They also mentioned that students should know what nuclear phase is correctly and should know chromosomes prior to learn meiosis since they have lots of misconceptions about chromosome during cell division.

### 1. The Effects of Background concept on the Understanding of Meiosis

Table 2 shows the achievement of meiosis background concepts including meiosis itself. A close look into the achievement of concepts reveals that the concept of gene topped the list at 75.6%, followed by mother cell and daughter cell at 71.5%, nuclear phases at 61.4%, chromosomes 61.4%, mitosis 59.8%, sexual reproduction - asexual reproduction 56.8%, meiosis 55.3%, cell cycle 51.7% and germ cell at the lowest with only 44.1%.

From this, it is found that the achievement of all the background concepts except for reproduction cell and cell cycle appeared higher than that of meiosis. This clearly shows, therefore, that this background concepts are more easy to learn than to learn meiosis.

Next in order to investigate how background concepts on meiosis affects the understanding of students on meiosis, achievement of all students was analyzed and divided into 3 groups according to that: advanced, intermediate and low.

To find out whether the average of each group's achievement related to each background concept has statistical significance, this study conducted one-way ANOVA analysis. That result (Table 3) shows as follows: the difference among the averages of three groups was 5% statistical meaningful in all 8 background knowledge. Moreover, based on post-hoc test using Scheffe statistics, it was confirmed that there is a significant difference in the averages of three groups. This result, shows that students according to achievement level have different background concept on meiosis. And we identified that there were some differences about background concepts for achievement level.

And Table 4 shows the performance of the background concept according to achievement of meiosis. A deep look on the difference of achievement among 3 groups reveals that in advanced group mother cell - daughter cell concepts were the highest of 89.9%. In other words they were perceived as relatively easy concepts but showed the widest gap with the low group. The concept of nuclear phases, on the other hand, had the least difference in achievement between the advanced and the low group. It is concluded, therefore, that the students in low group don't fully know the concepts of mother cell - daughter cell more

**Table 2**

*Achievement on meiosis background concept*

| concepts | achievement(%) | concepts | achievement(%) |
|---|---|---|---|
| gene | 75.6 | sexual reproduction · asexual reproduction | 56.8 |
| mother cell · daughter cell | 71.5 | meiosis | 55.3 |
| chromosomes | 61.4 | cell cycle | 51.7 |
| nuclear phases | 61.4 | reproduction cell | 44.1 |
| mitosis | 59.8 | | |

**Table 3**

*One-way ANOVA analysis of background concepts among three groups by achievement on meiosis* M(SD)

| variation \ group | advanced group N=462 | intermediate group N=578 | low group N=546 | F value |
|---|---|---|---|---|
| nuclear phases | 2.8[ab**] (.84) | 2.5[ac] (.96) | 2.0[bc] (1.11) | 69.693* |
| chromosomes | 3.0[ab] (.89) | 2.4[ac] (1.06) | 1.9[bc] (1.06) | 169.745* |
| mitosis | 3.1[ab] (.92) | 2.4[ac] (1.17) | 1.6[bc] (1.11) | 231.302* |
| sexual reproduction – asexual reproduction | 2.9[ab] (1.11) | 2.3[ac] (1.17) | 1.6[bc] (1.06) | 176.258* |
| reproduction cell | 2.3[ab] (.94) | 1.7[ac] (.92) | 1.2[bc] (.92) | 170.437* |
| gene | 3.5[ab] (.69) | 3.1[ac] (.90) | 2.5[bc] (1.11) | 148.965* |
| mother cell – daughter cell | 3.6[ab] (.69) | 2.9[ac] (1.09) | 2.1[bc] (1.28) | 251.724* |
| cell cycle | 2.7[ab] (.97) | 2.0[ac] (1.01) | 1.5[bc] (.96) | 182.375* |

* $p<.05$, ** : Scheffe statistics

**Table 4**

*The achievement of background concepts according to achievement of meiosis*

| achievement of meiosis background concepts | the advanced group N=462 (%) | the intermediate group N=578 (%) | the low group N=546 (%) |
|---|---|---|---|
| nuclear phases | 70.4 | 62.9 | 52.2 |
| chromosomes | 77.2 | 61.9 | 47.6 |
| mitosis | 78.9 | 61.2 | 42.0 |
| sexual reproduction – asexual reproduction | 73.6 | 58.6 | 40.6 |
| reproduction cell | 59.3 | 43.3 | 32.2 |
| gene | 88.0 | 77.6 | 63.1 |
| mother cell – daughter cell | 89.9 | 74.5 | 52.6 |
| cell cycle | 67.5 | 52.1 | 37.8 |

than students in the advanced group, though they know the concept of nuclear phases. But students in all groups don't fully know the concepts of reproduction cell because each group's achievement is the lowest.

### Multiple Regression Analysis

Table 5 shows the effects of background concept on achievement of meiosis using multiple regression analysis. The variables explaining the achievement of meiosis were 7 background concepts (except nuclear phases) and the most meaningful concept was mother – daughter cells. This was followed by mitosis, cell cycle, reproduction cell, gene, chromosomes and sexual reproduction – asexual reproduction. As for $R^2$, an indicator of how influential each variable is, the influence appeared to be 27.5%, 8%, 5.2%, 1.7%, 1.4%, 1.0% and 0.7%, and for total variable influence at approximately 45.5%.

Moreover, $\beta$ (standardized partial-regression coefficients), a regression coefficient that standardized the descriptivity of each independent variable, was as follows: mother cell – daughter cell at 0.192, mitosis 0.173, cell cycle 0.173, reproduction cell 0.115, gene 0.115, chromosomes 0.110 and sexual reproduction – asexual reproduction 0.099.

According to Jeong *et al.*(2010), biology teachers suggested that nuclear phases is the most for background concept on meiosis. But nuclear phases has a correlation with meiosis but don't has a influential effect with meiosis in this study. This result shows that there are differential perceptions between teachers and students for background concepts on meiosis.

In comparison with background concepts of meiosis based on previous survey of high school biology teachers, the concept of nuclear phases gained the largest number of the teacher responses followed by chromosomes, mitosis, sexual reproduction, germ cell, gene, mother cell and cell cycle. Although nuclear phases revealed meaningful correlation, it was not influential background concept. The concepts of mother cell - daughter cell appeared to be the most influential ones. This implies that what teachers consider as important background concept is different with what students consider as the important influence on their understanding of meiosis. Subsequently, it could be argued that having good understanding of the concepts of mother cell and daughter cell is necessary to learn meiosis, since the surveys showed that these concepts had the largest influence on the students' understanding of meiosis.

According to the achievement of meiosis, all the students were divided into 3 groups: the advanced, the intermediate and the low group. Of 1,586 students, 462 (29.13%) belonged to the advanced group, 578 (36.44%) in the intermediate group and 546 (34.43%) in the low group.

This study first looked into how meiosis correlates with the background concepts of meiosis for advanced group, whose achievement of meiosis is the highest at 29.13%. A close examination of the group's correlation coefficient between meiosis and background knowledge unveils that the concepts of nuclear phases and genes have no statistic correlation, and that cell cycle, chromosomes, reproduction cell, mitosis, mother cell - daughter cell and sexual reproduction - asexual reproduction have significant correlation at level of 5%. This could be due to the fact that the perceptions between the advanced and low groups on the concepts of nuclear phases and genes have a relatively small difference and very little influence on how students understand meiosis, as indicated in the achievement of background concept by meiosis as shown in Table 4. In addition, because the concept of genes was rated 88.0% in the achievement of gene for the advanced group, it is assumed that the advanced group has relatively good knowledge of genes, thus leaded to having little influence on the achievement of meiosis.

The relation between meiosis and background concept in the advanced group through multiple regression analysis is shown in Table 6. Analysis results reveal that the concepts of cell cycle and

**Table 5**

*Results from the multiple regression analysis of all students*

| variables | R | $R^2$ | $R^2$ variation | B | SE B | $\beta$ | t-value |
|---|---|---|---|---|---|---|---|
| mother-daughter cell | .525 | .275 | .275 | .264 | .033 | .192 | 8.021* |
| mitosis | .596 | .355 | .080 | .236 | .032 | .173 | 7.458* |
| cell cycle | .638 | .408 | .052 | .266 | .033 | .173 | 7.982* |
| reproduction cell | .652 | .425 | .017 | .189 | .036 | .115 | 5.248* |
| gene | .662 | .439 | .014 | .193 | .036 | .115 | 5.343* |
| chromosomes | .670 | .448 | .010 | .165 | .034 | .110 | 4.883* |
| sexual reproduction- sexual reproduction | .675 | .455 | .007 | .135 | .030 | .099 | 4.426* |

*$p<.05$

chromosomes are considered as important, with influence rate of 6.4% and 3.5%, respectively, total to 10% influence. On comparing all students, the reason for having smaller variables, which influence the achievement of meiosis, is that students in the advanced group have relatively better understanding of all concepts except cell cycle and chromosomes, thus leaded to having no influence on the understanding of meiosis.

The study then moved to know the correlation between meiosis and background concept of students in the intermediate group (representing 36.44%) according to achievement of meiosis. This group reveals that all the 8 background concept have statistically significant correlation at 5% level. It was explained that concepts of mother cell – daughter cell have the highest correlation with meiosis, followed by mitosis, chromosomes, germ cell, nuclear phases, cell cycle, genes and sexual reproduction – asexual reproduction in that order,.

Moreover, Table 6 shows the results from the multiple regression analysis of how the background concept of student in the intermediate group affects the achievement of meiosis. It is showed that the most influential concepts among the 8 background knowledge in accomplishing meiosis according to the intermediate group, are mother cell – daughter cell, mitosis, chromosomes and nuclear phases of the relevant concept of mother – daughter cell represented the rate of 5.4%, mitosis 1.8%, chromosomes 1.1% and nuclear phases 0.8%, for total combined influence of 9.1%.

Finally, close look of the correlation between meiosis and background concept in the low group (representing 34.43%) reveals that 7 background concepts (excluding germ cell) have significant correlation at 5% level. The low group did not place a significant statistical significance to the concept of reproduction cell perhaps because they do not have sufficient concept formation of reproduction cell as found in Table 4, which shows that the low group gave reproduction cell in the lowest achievement at 32.2%.

Table 6 shows the results from the multiple regression analysis on how background concept of the students in the low group affects achievement of meiosis. The multiple regression analysis of the low group finds out that the relevant concept of mother cell – daughter cell, nuclear phases and gene are considered as most influential in accomplishing meiosis. Their influence is rated as mother cell – daughter cell 5.7%, nuclear phases 1.8% and gene 0.9%, for total combined influence of 8.4%.

**Table 6**

*Results from the multiple regression analysis according to the achievement*

| | variables | R | $R^2$ | $R^2$ variation | B | SE B | $\beta$ | t-value |
|---|---|---|---|---|---|---|---|---|
| advanced group | cell cycle | .254 | .064 | .064 | .104 | .022 | .211 | 4.641* |
| | chromosomes | .315 | .100 | .035 | .103 | .024 | .192 | 4.228* |
| intermediate group | mother cell – daughter cell | . 232 | .054 | .054 | .070 | .020 | .152 | 3.521* |
| | mitosis | .268 | .072 | .018 | .045 | .018 | .107 | 2.496* |
| | chromosomes | .287 | .083 | .011 | .047 | .020 | .099 | 2.322* |
| | nuclear phases | .302 | .091 | .008 | .049 | .022 | .095 | 2.296* |
| low group | mother cell – daughter cell | .238 | .057 | .057 | .095 | .025 | .152 | 3.821* |
| | nuclear phases | .274 | .075 | .018 | .078 | .028 | .107 | 2.780* |
| | gene | .290 | .084 | .009 | .065 | .029 | .095 | 2.276* |

*$p<.05$

## Ⅳ. Discussion

To better understand how background concept presented by high school biology teachers affects the understanding of high school students on meiosis, this study conducted survey on 10th and 11th grade students about the concept of meiosis and their background concept on meiosis. Based on the results, this study further analyzed the effects of the students' achievement of meiosis on their understanding of meiosis.

First, in looking into the background concept of meiosis presented by high school biology teachers, the concept of nuclear phases was selected by the most teachers. This was accord with the study by Jeong et al (2010). This is the reason why that, in explaining the meaning of meiosis, most teachers emphasize on the fact that nuclear phase with half number recovers the number of chromosomes through the fertilization of reproduction cell. Moreover, it is also assumed that they emphasize the fact that it has the largest differences from mitosis and that nuclear phase reduces its number from diploid phase (2n) to haploid phase (n). It is important but difficult for students to understand (Hwang and Lee, 2000). The high school biology teachers then thought chromosomes, mitosis and sexual reproduction as the second most important concepts.

Also this study, that a great number of teachers consider sexual reproduction as important background concept, is coincidence with the study by Knippels *et al.*(2005), which also asserted that sexual reproduction should be explained in correlation with meiosis and genetics. On the other hand, the relatively small number out of 10 teachers presented homologous chromosome, which was base concept to understand the basic principles of Mendelism by Browning (1988). In comparison with previous studies arguing the learning of homologous chromosomes prior to meiosis is needed by Bae *et al.*(2007), this results show much smaller number of teachers. However, this result agree with the study conducted by Lee (1989) who pointed out that meiosis is often misunderstood because of the conceptual ambiguity in homologous chromosome concept.

Next to know how they actually teach genetics concept in their actual classes, it was interviewed by all 3 teachers out of 48 teachers. All 3 teachers represented the concept of nuclear phases to be taught first. As shown in the previous survey results, nuclear phase is used to emphasize the meaning of meiosis more than any other background concept and that it is necessary to explain the reduction by half in numbers, which is significantly difference from mitosis. Accordingly, students should accurately comprehend what the nuclear phase is. Furthermore, it was mentioned that as a great number of students have misunderstanding the behaviors of chromosomes during cell division (Chung and Kim, 2002), they should be fully and correctly aware of chromosomes. In particular, as the behavior of homologous chromosome and the concept of division are important (Bae *et al.*, 2007), it is necessary for students to know the concept of homologous chromosome before learning meiosis.

Regarding how students' achievement of meiosis background concept affects his or her understanding of meiosis, the achievement of meiosis was analyzed, classifying into 3 categories: advanced, intermediate and low. In the advanced group, all the background concept except nuclear phases and gene had significant correlation with the achievement of meiosis. In this group cell cycle and chromosomes are the most influential concepts primarily due to the fact that nuclear phases and gene are background concept with relatively small difference between the advanced group and the low group.

Table 4 reveals that these concepts have little influence on the students' understanding of meiosis, as indicated in the achievement of background concept by meiosis. In addition, since the advanced group gave genes the rate of 88.0% in the achievement of gene, it can be

assumed that this group has relatively much knowledge of genes, thus resulted to a little influence on the achievement of meiosis. For the intermediate group, on the other hand, it appeared that all 8 background concepts significantly correlate with the achievement of meiosis, and the concepts of mother cell - daughter cell, mitosis, chromosomes and nuclear phases are most influential. Compared with the advanced group, in the intermediate group more variables that affect the understanding of meiosis are found.

Moreover, nuclear phases and gene had significant correlation, while these 2 concepts had no correlation in the advanced group. In particular, nuclear phases appeared to be an influential variable. This seems to be due to the intermediate group's insufficient concept formation is required before learning about meiosis. Finally, for the low group, it appeared that all the background concept except reproduction cell have significant correlation.

The group placed the relevant concept of mother cell - daughter cell, nuclear phases and gene as the most influential ones. Similarly with the intermediate group, the low group showed that nuclear phases and gene have significant correlation with the achievement of meiosis and that the 2 said concepts greatly influence the achievement of meiosis, as opposed to that of the advanced group. This seems to be due to the fact that other background concept is learned in middle school but the concepts of nuclear phases and gene are not mentioned until high school. In addition, the advanced group has relatively better conceptual formation whereas the 2 other groups have insufficient conceptual formation on nuclear phases and gene, thus it affects the achievement of meiosis. Interestingly, mother cell - daughter cell appeared to be the most influential background concept for both the intermediate and low groups, but was considered of little influence by the advance group. Therefore, it can be thought that mother cell and daughter cell are easy concepts with the higher achievement, thus leading the advanced group to have much formation of concept while having larger influence on the other 2 groups' understanding of meiosis due to the other groups' insufficient conceptual formation.

## Ⅴ. Conclusion

The effects of background concept related to meiosis on the understanding of meiosis vary by accomplishment of meiosis and grade level of high school students. Background concept is important role to form knowledge students will learn. Background concept , therefore, should be taught completely considering students' achievement level prieviously in order to agree with curriculum's need. Also biology teachers are needed to reach an agreement of background concepts for other concepts which are important in biology but difficult to students. In this study, it is necessary for teachers to identify background concept of meiosis prior to the meiosis class and to design methods of teaching and learning that consider accomplishment and grade level. As for an advanced group, whose students have not adequately formed relatively difficult concepts such as cell cycle and chromosomes, these topics should be emphasized when they are taught. For students of an intermediate group, on the other hand, it is necessary to gradually form the concepts by teaching from the easy concepts, such as mother cell - daughter cell and nuclear phase, to the relatively difficult ones, such as chromosomes and mitosis. Finally, for students of a low group, who have poorly formed knowledge of such easy concepts as mother cell - daughter cell, nuclear phases and gene, should be taught basic background knowledge before learning about meiosis. Furthermore, as confusion between mitosis and meiosis greatly affected the accomplishment of meiosis in 10th grade students, students such as these should focus on the differences between mitosis and meiosis. On the other hand, repetition and in-depth learning

of meiosis could confuse 11th grade students. So teachers should teach the overall background concept in detail for them.

This study surveyed 10th and 11th grade students on the concept of meiosis, which is actually a concept taught to 9th grade students now. Accordingly, when an additional survey is conducted in the future for 9th grade students, it may demonstrate not only differences by grades but also show a connection between middle and high school. Furthermore, since the concepts of mitosis greatly overlap with meiosis they should be taught with meiosis. This approach may supply important basic data for teaching the comparison between meiosis and mitosis, if an analysis of the effects of meiosis background concept on the understanding of mitosis is conducted.

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