Relevance of Human Chromosome Analysis Activities against Mutation Concept in Genetics Course

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Abstract. This study describes the relevance of human chromosome analysis activities against genes and chromosomes mutation in genetics course. This activities is to analyze the images of photomicrograph chromosomes of various cases and disorders caused by irregularities of human chromosome number or structure in the form of a karyotype. The purpose of this analysis is to gain relevance practicum against the theory course. Object of this research is the lab activities of analysis human chromosomes. Source of data derived from syllabus documentation, SAP, genetics lecture, lab instructions, journals genetics, and 40 respondents taken by purposive sampling. The results showed analysis of human chromosomes activities can only preach of chromosome mutation concept only. The use of inquiry-based lab project can be to preach more concept of gene mutations with more knowledge coverage, the allocation of more time, greater cost, fewer students so that it matches given to undergraduate student biology deepen molecular genetics. Conclusion of this studies, analysis of human chromosomes activities is relevant to preach human chromosome mutation concept but can not be used to preach concept of gene mutations.

1. Introduction
Chromosomes are the structures inside the cell that contain genetic information. The chromosome is place of the genetic material DNA and RNA. Chromosome formed from DNA binds to histone proteins to form nucleosomes and form a compilers of chromatids windings (See Figure 1).[1]
Based on the location of the centromere, a chromosome can be divided into several forms covering [2]:

- **metacentric**, if the centromere is located in the middle of the chromosome so that the chromosomes splits into two arms are almost as long.
- **submetacentric** if the centromere is located towards one end of the chromosome so that the chromosomes divided into two arms of unequal length,
- **acrocentric centromere** which lies near the ends of chromosomes so that one arm being very short and others are very long.
- **Last is telocentric chromosomes** that if the centromere is located at the ends of chromosomes that chromosome consists of only one arm. Based on the type, chromosomes consisting of autosomes (chromosomes body) and gonosom (the sex chromosomes).

All total genetic information in a cell or organism is called the genome. The genome has the potential to mutate the changes in chromosomes, genes and DNA. [3] During cell division by mitosis and meiosis, the possibility of the occurrence of an error in cell division will potentially result in chromosomal abnormalities. Damage to chromosomes will potentially on DNA damage and genomic instability. The chromosomal abnormality could be loss or increase of chromosomal.

Abnormalities in chromosomes, divided into two covering abnormalities structural changes and change of amount chromosome number. The change of the amount of chromosome such as duplications, deletions, inversions and translocations of chromosomes. [4] Deletions are missing or the loss partly because of a broken chromosome. Duplication can occur when a part of the chromosome has a gene are repeated because of the length of a chromosome arm. Inversion is a chromosome that has the gene sequence is reversed due to the 180 degree rotation of the chromosome which then form a loop. Loop that has been formed is broken and ultimately linked back. Translocation occurs because a part of a chromosome segment moves to another chromosome. Chromosomal abnormalities occur not only because of changes in the chromosomes but may be due to changes in the number of chromosomes. Such changes include euploid and aneuploid chromosome. Euploidy is a situation when the number of chromosomes doubled from the number of chromosomal origin, for example, is the watermelon without seeds. Aneuploid is the state of an organism to excess or shortage of a particular chromosome. Individuals with this disorder are aneuploid typically caused by nondisjunction. This is an example of chromosomal abnormalities such as Cry du Chat syndrome, Wolf-Hirschhorn Syndrome, Down Syndrome Jacobsen Syndrome, Edwards Syndrome, Turner Syndrome Klinefelter's syndrome.[5]

There are methods that can be done to analyze chromosomal abnormalities in humans, by analyzing the chromosomal karyotype or chromosomal depiction. [6] The method is karyotyping. Karyotyping analysis using a microscope to arrange karyotype. Karyotyping can be used to check an abnormal number of chromosomes or chromosomal defects associated with congenital abnormality or
syndrome.[7] This technique is done by analyzing the images / photomicrograph suspected chromosome abnormalities. Chromosome image analysis performed to detect the presence of chromosomal damage in the amount or structure. Analysis of chromosomal photomicrograph done in lab activities is done so that undergraduate students can recognize disturbances or abnormalities in humans caused by aberrations chromosome number and structure. With photomicrograph analysis of chromosomal abnormalities in the various cases and students are expected to understand the mutations in humans.

2. Methodology
This research is a descriptive study that describes the relevance of human chromosomes analysis activities with mutation concept in genetics course. Object of this research is the activities of human chromosomes analysis. Source of data derived from syllabus, satuan acara perkuliahan, lab instructions, and journals of genetics. Techniques of data retrieval by studying documentation, literature studies, surveys and direct observation.

3. Results dan Conclusion
Chromosomal mutation is a change that can occur when the process of gametes cell division or meiosis, it caused by mutagen such as a chemical substances and radiation. As a result of the mutation is that there are changes in the number or structure of chromosomes in the cell changes and in case of chromosomal mutations will affect the whole chromosome in the body. Chromosomal mutation often considered different from gene mutations. Gene mutation occurs in one gene in the chromosome, but chromosome mutation occurs on a large scale. It will affect an important part of chromosome because many genes are changed and influenced by a single mutation.

A normal human would have a chromosomal karyotype arrangement with the number 46 or 23 pairs as shown below (See Figure 2). If there is an excess or shortage of quantity or a different form in the chromosomes then certainly it is a chromosomal mutation. Analysis of human chromosomes performed by creating a chromosome slide culture derived from cell culture or human tissue culture and stop its division process during metaphase. Through the microscope, karyotype observed in take pictures through images or through a microscope connected to a computer and processed using a specialized program. Generally karyotype done by taking the image of the cell at the time of metaphase chromosomes so obvious then cut each chromosome image and identify each chromosome to be made its ideograms (See Figure 3).

The technique of making photomicrograph of chromosomes is the technique in the process has a fairly high level of complexity. In the lab activities, undergraduate students already get an overview photomicrograph of chromosomes directly from the lab instructions or other available sources such as the internet so no need to make chromosome slide culture.

The process of making photomicrograph of chromosomes that can actually be done by experts sitogentika by making chromosome slide culture. The technique of making slide culture to do with taking organ cells taken from the body of the young organism (larvae or seedlings of the organism) and cultured tissue or cell cultures. The technique of making chromosome slide culture using tissue culture is a technique that is relatively cheap and easy but the technique of making slide culture chromosome using cell cultures will be more clearly seen. Almost all dividing cells can be used as blood cells, skin, amniotic fluid. The cells in culture by providing proper nutrition for growth so that the cell can divide. Some cells grow both the harvesting and stops growing at mitotic division metaphase stage. Furthermore chromosome are colored and performed an analysis of the number and the abnormalities that occur.
After making the culture cell and staining the chromosome slide, chromosomes are ready to be analyzed. Chromosome slide culture photographed in photographs to obtaining images which will then be analyzed chromosomes. Photographing advised to focus on the specimen so it can be seen clearly karyotype desired. The photographs processed using software on a computer so it can make the effects are clear in explaining the morphology and behavior of chromosomes.

Lab activities to learn about mutation in this course, performed by analyzing human chromosome without making chromosome slide culture. The time for the process is not sufficient for the course. Furthermore, techniques for making cell culture, have not conceived to the undergraduate students for making chromosome slide culture. It is requires complex techniques as practiced by experts citogenetika.

Appliance and ingredient used in lab analysis of human chromosomes include: scissors, photomicrograph of chromosomes, legal-sized paper and glue. The instruction is done is by cutting pictures of chromosomes from each set of results photomicrograph and prepare the results of the clipping into each group according to the number of chromosomes that make up the composition of
karyotype. Grouping based on the International System for Human Cytogenetics Nomenclature (ISCN) where human chromosomes grouped into seven groups as in Table 1.

Table 1. Grouping of Chromosome

| Grouping | Number Of Chromosome | Description chromosome |
|----------|----------------------|------------------------|
| Group A  | Chromosome 1-3       | Metacentric chromosomes are large and easily distinguished from the others because of its size and location of the centromere |
| Group B  | Chromosome 4-5       | has two large-sized chromosome sub metacentric |
| Group C  | Chromosome 6-12, X   | Metacentric chromosomes and medium-sized sub metacentric |
| Group D  | Chromosome 13-15     |acrocentric chromosomes of medium size and has satellite |
| Group E  | Chromosome 16-18     | Metacentric chromosomes and small-sized sub metacentric |
| Group F  | Chromosome 19-20     | Very small mmetacentric chromosome |
| Group G  | Chromosome 21-22, Y  | Acrocentric chromosomes are very small and have satellites except for Y chromosome |

Photomicrograph chromosome snipped and prepared in accordance with the above table grouping to form a karyotype as below (See Figure 4). After getting the results of the karyotipe arrangement, undergraduate students are allowed to give description such as type of sex, normal / abnormal karyotype and formulas for each are arranged like the picture below (See Figure 5).
Figures 5. Normal karyotype and abnormal karyotype.

Source: Google.co.id

The image above is one of the activities of human chromosomes analysis of. In the picture left shows normal female karyotype analysis chromosomes. In the right image seen on number 23 chromosome there is only one chromosome X, normally female should have XX chromosomes. This indicates a reduction in XX chromosomes so that the number of chromosomes that is only 45. Through literature review, the reduction in the number of chromosomes that occurs on a sex chromosome mutations that turner syndrome.

Turner syndrome is a hereditary disease is the result of sex chromosome abnormalities, which only affects women. This disorder occurs when the X chromosomes partially or completely missing (monosomy). Normal human being would have 23 pairs of chromosomes and its gender will be determined from one of the pair of chromosomes that exist. A man will have a X and a Y chromosome (XY), whereas a woman has two X chromosomes (XX). Women who have Turner syndrome have one X chromosome is abnormal or missing entirely.

This syndrome can cause a variety of medical disorders and in physical development, such as height lower, failing to start puberty, infertility, heart defects, difficulty adapting socially, and difficulties in learning some things. Physical characteristics often appear on the incidence of Turner syndrome are shorter height and ovaries are underdeveloped. Ovaries less developed can lead to sterility and absence of menstruation, heart problems, kidney, and thyroid gland. Furthermore, Turner syndrome can also cause ear disorders and bone disorders.

Based on the study syllabus about mutation concept, the purpose of this course is the undergraduate students can understand chromosome mutation and gene mutation. Where to chromosome mutations, which are mutations should be understood based on the structure, number and can be explained as a result of these mutations. For the gene mutation, undergraduate student must understand the type of mutation of the gene, the molecular basis of gene mutations, the role of the type of mutagen and application of gene mutations. The lack of analysis of human chromosomes activities scope can not provide knowledge about the concept of gene mutations.

Gene mutations also known as point mutations are mutations that occur due to changes the base pairs of the DNA of a gene. DNA changes cause changes in RNA codons, which eventually led to changes in certain amino acids in the proteins made. There are two mechanisms of gene mutations, substitution of base pairs and the addition or subtraction of base pairs. The study of gene mutations (abnormalities in genes) can be done using Caenorhabditis elegans in molecular genetics research.
activities. The nematode *Caenorhabditis elegans* is a free-living in soil, has long been used as a model organism for research on animal development, including neural development, because it is easily cultivated and easy to analyze their genetic structure. NASA even uses *Caenorhabditis elegans* to investigate effects of zero gravity on muscle development and physiology to send samples of the worms into space for two weeks. Nematode *Caenorhabditis elegans* is one of the species of life that has largely been well studied and has been used as a biological model organism for genetic and developmental studies. The creature was the first multicellular organism with a complete DNA sequence obtained.

Laboratory activities using *Caenorhabditis elegans* requires a four-week period in which students investigate whether *Caenorhabditis elegans* can be used to study disease genes in humans. In this activity students perform comparative analysis between wild type C. elegans with *Caenorhabditis elegans* is already in a deletion mutation in a way to understand the effects of the deletion of the gene encoding the RNA and protein. In this study, students also observed whether the RNA Interference (RNAi) can affect the human gene and evaluate whether RNAi can show similarities phenotypes result from gene mutations (deletion). In this research undergraduate student can learn about DNA, replication, transcription, translation, mutagenesis, and regulation of gene expression. This activity prepared by the method of inquiry titled practicum activities that stimulate undergraduate students to be able to do the experiment "whether *Caenorhabditis elegans* can be used as a good model for studying the function associated with the gene disease".

Results of this research research indicate that these activities can provide knowledge for undergraduate students with greater knowledge concept, greater cost, longer research time and the amount of undergraduate students fewer.

Two types of lab activities above shows a very clear distinction for the analysis of human chromosome activities using chromosome photomicrograph image analysis is a type of verification lab activities. It has the advantages such as low cost, a fewer time and can be done with amount of large number of undergraduate student. The disadvantage is unable to provide knowledge about the gene mutation. While in using the *Caenorhabditis elegans* on inquiry lab activities can can provide a lot of knowledge in a series of researchl activities. The weakness is required large of cost, not suitable for amount of large number students and more spent time, energy.

When this research activities applied in course, using a photomicrograph chromosome to analyze human chromosome is enough to preach concept of mutation to undergraduate students. When using *Caenorhabditis elegans* in lab activities can be applied to biology students who want to deepen the molecular biology.

4. Conclusion
This study describes the relevance of human chromosome analysis activities against genes and cromosomes mutation in genetics course. This activities is to analyze the images of photomicrograph chromosomes of various cases and disorders caused by irregularities of human chromosome number or structure in the form of a karyotype. The purpose of this analysis is to gain relevance practicum against the theory course. Object of this research is the lab activities of analysis human chromosomes. Source of data derived from syllabus documentation, SAP, genetics lecture, lab instructions, journals genetics, and 40 respondents taken by purposive sampling. The results showed analysis of human chromosomes activities can only preach of chromosome mutation concept only. The use of inquiry-based lab project can be to preach more concept of gene mutations with more knowledge coverage, the allocation of more time, greater cost, fewer students so that it matches given to undergraduate student biology deepen molecular genetics. Conclusion of this studies, analysis of human chromosomes activities is relevant to preach human chromosome mutation concept but can not be used to preach concept of gene mutations.
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