I already knew about graph analysis with R or basic terminology in graph theory, because my research theme was gene network analysis derived omics data when I was an undergraduate student. However, I learned about some mathematical handling of graph theory such as Laplacian matrix for the first time in this class. As this paper seemed to require the readers to have these knowledges beforehand, I think this class helped me understand the method using graph theory in the life science field.

The focus of this review article is to provide a comprehensive and unified survey of machine learning and graph theory algorithms for network analysis in precision oncology. The first section of this review article described that the various type of the biological network and the database of them. These networks can be represented as graph and we use the knowledge studied in this class for the examining the characteristics of them. The scenarios for the integration of genomic data with molecular networks are mainly classified to three type, model-based integration of whole-genomic profiles and a network, preprocessing integration to detect network-based features or post-analysis of oncogenic alterations in networks.

One of the technique of model-based integration is the graph Laplacian regularization, which used graph Laplacian matrix **L** among genes derived from network information as the regularization term  where **β** represent the regression coefficient of genes for the phenotype. Laplacian matrix is the node by node matrix derived from a graph and the one of the topic studied in the class. The diagonal element of L represents the degree of each node and other element represent 0 or -1 depending on there is edge between two nodes. the regularization term is expressed as follow:



where and are the regression coefficient of i-th and j-th gene for the phenotype and lij is the I,j the element of **L.** It is considered that this regularization term suppresses the value of the regression coefficient for nodes with larger degree. In addition, it promotes to equalize the signs of the two connected nodes.