2nd

a. Summary:

Peter McCullagh's 1980 paper in the Journal of the Royal Statistical Society explores regression models for ordinal data, presenting a class of models utilizing the ordinal nature of data without relying on arbitrary scoring systems. In the paper we could see models like proportional odds and proportional hazards, treating them as multivariate extensions of generalized linear models. He tells us about some fitting methods, including iteratively reweighted least squares (ILRS) and maximum likelihood, and presents the proportional odds model, with its application with tonsil size data. We can also see the proportional hazards model, demonstrated with the taste-testing data.

The paper also discusses about the non-linear models, multivariate ordinal responses and bivariate ordered responses. The conclusion of the paper helps us with model selection, interpretation, verification and comparison. It also tells us the importance of quantitative statements over significance tests. The paper also talks about the limitations, including sparse data challenges, concerns about uniqueness of estimates, and sensitivity to contamination, while highlighting the complexities in link function selection and distinguishing between symmetric and asymmetric models.

Difference between ordinal regression and multi class classification:

1. The first difference would be the modelling approach. The purpose of ordinal regression is to model a relationship between ordinal response variables and predictor factors. While for multi class classificational it is to classify the data points into one of several discrete classes or categories without taking the ordinal structure of the response into consideration.

2. Likelihood:
   - Ordinal: These models are designed for categorical outcomes. The outcomes of ordinal have a meaningful order with unequal intervals between them. The likelihood in this regression mainly focuses on the probabilities of an observation that belongs to or above a particular category, given the predictor variables.
   - Multi-Class: These models are also designed for categorical outcomes, but they would not have a specific order among them. The likelihood in this estimates the probability of an observation belonging to each class

3. Odds ratio:
   - Ordinal: Again, here also similar to likelihood, the odds ratio tells us about the odds of an observation belonging to a particular category or higher
   - Multi-Class: Here, we predict the probability of the object in each class, and the highest one is predicted

How is it different from Regression problems:

1. Nature of dependent variables:
   In ordinal, the dependent variables have ordered categories, with unequal intervals. While in standard regression, they are continuous and can take any actual value.

2. Model Formulation:
   In ordinal, we use models like the proportional odds model to maintain the response variable's ordinal structure, on the other hand standard regression models use the polynomial equations to give the relation between predicted values and dependent variables