ON THE CLASSIFICATION AND NOMENCLATURE OF THE
FAMILY ENTEROBACTERIACEAE

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ABSTRACT. While the genera and subgenera of the family Enterobacteriaceae are defined by biochemical (mostly fermentative) methods, the species of all established genera are diagnosed primarily by serological methods. In contrast to this, genera and species in orthodox classification are defined only by biochemical methods.

To reach an agreement, it is proposed to designate the "species" of the orthodox classification as subgenera and to define the species according to the modern classification as groups of related serofermentative phage types.

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In E. van Oye's book "The World Problem of Salmonellosis" F. Kauffmann has given the following classification of the family Enterobacteriaceae:

Tribes	Genera
I. <u>Eschericheae</u>	I. <u>Escherichia</u> II. <u>Shigella</u> III. <u>Salmonella</u> IV. <u>Citrobacter</u>
II. <u>Klebsielleae</u>	I. <u>Klebsiella</u> II. <u>Enterobacter</u> III. <u>Hafnia</u> IV. <u>Serratia</u>

Tribes	Genera
III. <u>Proteae</u>	I. <u>Proteus</u>
	II. <u>Morganella</u>
	III. <u>Rettgerella</u>
	IV. <u>Providencia</u>

While the tribes Eschericheae and Proteae are written in this manner in Bergey's Manual 6th edition, they are written Escherichiae and Proteae in the 7th edition.

The genera are subdivided serologically into species which are groups of related serofermentative phage types (Kauffmann, 1961). They are designated either by name (as in the genus Salmonella) or by antigenic formula (as in the genus Escherichia) or by letters and numbers (as in the genus Shigella).

Therefore, it is necessary to change the Bacteriological Code that species can be designated by name, by antigenic formula or by letters and numbers.

Independent from this serological subdivision of a genus into species, the genus may be subdivided into biochemically defined subgenera.

A genus is defined as a group of related species and a tribe as a group of related genera.

As mentioned in a previous paper "On the species-definition," we have two different classifications which we can call the orthodox and the modern classification. The orthodox classification is represented by Bergey's Manual and the modern classification by the 1st Report of the Salmonella Subcommittee in 1934.

In the orthodox classification the species are defined only by biochemical methods, whereas in the modern classification the species are defined biochemically as well as serologically and are subdivided into serofermentative phage types. In contrast to genera and subgenera which are defined biochemically, the definition of species is based mostly on serological methods.

While the orthodox classification starts with the higher units, the modern classification begins from below. The higher groups are only biochemically defined and therefore badly defined. There are no sharp frontiers between these higher groups, they cannot be defined exactly. However, a species, like S. typhi-murium, can be defined exactly.

This is valid not only for the genus Salmonella, but also for other genera of the family Enterobacteriaceae.

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Familia Enterobacteriaceae

Tribus I. Eschericheae Bergey, Breed and Murray.

Genus I. Escherichia Castellani and Chalmers.

The genus Escherichia is subdivided serologically into species, defined as groups of related serofermentative phage types and designated by their antigenic formula. See Kauffmann: "The Serology of the Coli Group" and "Enterobacteriaceae."

The type species is Escherichia 1:1:7.

The genus may be subdivided into biochemically defined subgenera, independent from the above classification. Subgenus I is called Escherichia coli.

Genus II. Shigella Castellani and Chalmers.

The genus Shigella is subdivided serologically into species, designated by letters and numbers.

The type species is Shigella A 1.

The genus Shigella is very closely related to the genus Escherichia and may be regarded as a biochemically defined subgenus of Escherichia. The Shigella O antigens are either identical with or closely related to Escherichia O antigens and can be arranged into O groups like Escherichia O groups and subdivided serologically into species. These species = groups of related serofermentative phage types and are designated by the traditional symbols A 1, A 2, A 3 etc., B 1a, B 1b, B 2a, etc., or C 1, C 2, C 3 etc.

Independent from this serological classification, the genus Shigella may be subdivided into two biochemically defined subgenera:

Subgenus I = Shigella dysenteriae

Subgenus II = Shigella flexneri-boydii.

Shigella sonnei is added as a separate species.

Genus III. Salmonella Lignières.

The genus Salmonella is subdivided serologically into species, designated either by names or by antigenic formula.

The type species is Salmonella cholerae-suis.

Independent from this serological classification, the genus Salmonella is subdivided into three biochemically defined subgenera I, II and III (= Salmonella arizonae). See Kauffmann: "Die Bakteriologie der Salmonella Species" and "Das

Kauffmann-White Schema" in E. van Oye's book: "The World Problem of Salmonellosis." Kauffmann and Rohde: "Zur Vereinfachung der serologischen Arizona-Diagnose."

Genus IV. Citrobacter Werkman and Gillen.

The genus Citrobacter is subdivided serologically into species, designated by their antigenic formula.

The type species is Citrobacter 1:1 (1:1 means that the species are designated by antigenic formula).

The genus may be subdivided, independent from the serological classification, into biochemically defined subgenera. Subgenus I is called Citrobacter freundii.

Tribus II. Klebsielleae Trevisan.

Genus I. Klebsiella Trevisan.

The genus Klebsiella is subdivided serologically into species, designated by their antigenic formula.

The type species is Klebsiella 1:1.

Independent from this serological classification, the genus may be subdivided into biochemically defined subgenera. Subgenus I is called Klebsiella pneumoniae.

Genus II. Enterobacter Hormaeche and Edwards.

The genus Enterobacter is subdivided serologically into species designated by their antigenic formula.

The type species is Enterobacter 1:1. See Sedlák and Mačejovská; also Sakazaki and Namioka.

Independent from this serological classification, the genus may be subdivided into biochemically defined subgenera which are called: Enterobacter cloacae, E. aerogenes and E. liquefaciens.

Genus III. Hafnia Møller.

The genus Hafnia is subdivided serologically into species, designated by their antigenic formula.

The type species is Hafnia 1:1. See Sakazaki.

The genus may be subdivided into biochemically defined subgenera.

Genus IV. Serratia Bizio.

The genus Serratia is subdivided serologically into species, designated by their antigenic formula.

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The type species is Serratia 1:1. See Ewing, Johnson and Davis.

The genus may be subdivided into biochemically defined subgenera. Subgenus I is called Serratia marcescens.

Tribus III. Proteae Castellani and Chalmers.

Genus I. Proteus Hauser.

The genus Proteus is subdivided serologically into species, designated by their antigenic formula.

The type species is Proteus 1:1.

The genus Proteus is subdivided into two biochemically defined subgenera: Proteus vulgaris and Proteus mirabilis.

Genus II. Morganella Fulton.

The genus Morganella is subdivided serologically into species, designated by their antigenic formula.

The type species is Morganella 1:1. See Rauss and Vörös.

The genus may be subdivided into biochemically defined subgenera.

Genus III. Rettgerella Kauffmann.

The genus Rettgerella is subdivided serologically into species, designated by their antigenic formula.

The type species is Rettgerella 1:2. See Namioka and Sakazaki.

The genus may be subdivided into biochemically defined subgenera.

Genus IV. Providencia Kauffmann.

The genus Providencia is subdivided serologically into species, designated by their antigenic formula.

The type species is Providencia 1:1. See Ewing, Tanner and Dennard.

Independent from this serological classification, the genus Providencia may be subdivided into biochemically defined subgenera.

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With regard to the classification of Proteae, the reader is referred to the "Minority Report on the Tribe Proteae, 1962" by K. Rauss. The author is in complete agreement with this paper.

With regard to the serological subdivision of genera into species the following reviews can be mentioned: Kauffmann: "Enterobacteriaceae." Edwards and Ewing: "Identification of Enterobacteriaceae." Sedláč and Rische: "Enterobacteriaceae-Infektionen."

SUMMARY

The genera of the family Enterobacteriaceae are defined by biochemical (mostly fermentative) methods and may be subdivided into biochemically defined subgenera.

Independent from this biochemical classification, the species of all the established genera are diagnosed primarily by serological methods.

While the orthodox classification, represented by Bergey's Manual, is using only biochemical methods for the definition of "species," the modern classification, started by the 1st Report of the Salmonella Subcommittee, is based upon serological and biochemical methods.

To reach an agreement, it is proposed to designate the "species" of the orthodox classification as subgenera and to define the species according to the modern classification as groups of related serofermentative phage types.

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