Taxonomic Notes: an Aid to Formation of Bacterial Names

Chemical Terminology and Microbiological Nomenclature†

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The descriptions of most species of bacteria and yeasts, of many of the filamentous fungi and of some of the protozoa include criteria based upon physiology and relationships to chemical elements and compounds. Frequent reference to chemical changes produced by microorganisms and to the influence of chemical environments upon the cells has led to the proposal of names of bacterial taxa, particularly of generic names and of species (specific epithets), which have some chemical connotation. Etymologically some of the names proposed are good, others are ambiguous, still others are improperly formed. The problem of developing names of taxa and of epithets not only acceptable (legitimate) but etymologically defensible is not particularly difficult of solution, but a search of the literature of nomenclature has disclosed no adequate presentation of the special problem of Latinizing chemical names for use in forming words to be used as names of taxa or as specific epithets, particularly in microbiology.

Many generic names and specific epithets are based upon the Latin or Latinized names of chemical elements or compounds. The index to the seventh edition of *Bergey's Manual of Determinative Bacteriology* includes 75 names of bacterial genera that have some chemical connotation. This list as here given is by no means inclusive.

Names of Genera. *Acetobacter*, *Acetobacterium*, *Acetomonas*, *Aerobacter*, *Alcaligenes*, *Alginobacter*, *Alginomonas*, *Azotobacter*, *Azotomonas*, *Butyribacterium*, *Carboxydomonas*, *Caseobacterium*, *Cellfalcicula*, *Cellulomonas*, *Cellvibrio*, *Citrobacter*, *Cytophaga*, *Desulfovibrio*, *Ferribacterium*, *Ferrobacillus*, *Halobacter*, *Halobacterium*, *Halococcus*, *Halophilus*, *Hydrogenomonas*, *Hydrocrocis*, *Lactobacillus*, *Lactobacterium*, *Lactococcus*, *Methanobacterium*, *Methanococcus*, *Methanomonas*, *Methanosarcina*, *Nitrobacter*, *Nitrocystis*, *Nitrogloea*, *Nitrosococcus*, *Nitrosocystis*, *Nitrosogloea*, *Nitrosomonas*, *Nitrospira*, *Pectobacterium*, *Peptococcus*, *Peptostreptococcus*, *Propionibacterium*, *Protaminobacter*, *Saccharobacillus*, *Saccharobacterium*, *Saccharomonas*, *Siderobacter*, *Siderocapsa*, *Siderococcus*, *Siderocystis*, *Sideroderma*, *Sideromonas*, *Sideronema*, *Siderophacus*, *Siderosphaera*, *Siderotheca*, *Sporocytophaga*, *Sulfomonas*, *Sulfospirillum*, *Thiobacillus*, *Thiobacterium*, *Thioderma*, *Thiophysa*, *Thioploca*, *Thiosphaerella*, *Thiospira*, *Thiospirillopsis*, *Thiothrix*, *Thiovibrio*, *Thiovulum*, *Urobacillus*, *Urococcus*, *Urosarcina*.

There are also many specific epithets which are derived from Latin or are Latinized words (or phrases) denoting chemical elements or compounds. The following list of 109 such specific epithets is also taken from the *Bergey's Manual* index. It is illustrative, but not complete. Nouns used as specific epithets are listed in the nominative singular, adjectives are given in nominative masculine singular.

Words and phrases used as specific epithets. *aceticus*, *acetus*, *acetobutylicus*, *acetosus*, *acetylicus*, *acidum-lacticum*, *acidum-uricum*, *acidofaciens*, *acidominimus*, *acidophilus*, *acidulus*, *aerofaciens*, *aerofetidis*, *aerogenes*, *aerogenoides*, *alcalescens*, *alginicus*, *alginovor*, *ammonitagenes*, *amylifer*, *amylolyticus*, *amylosaccharobutylopropionicus*, *amylovorus*, *antibioticus*, *asaccharolyticus*, *biazoteus*, *butylicus*, *butyrum*, *butyricus*, *calx*, *caseus*, *caseolyticus*, *cellaseus*, *cellobioparus*, *celluloflavus*, *conjac*, *coproliticus*, *creatinovorans*, *cremor*, *cytophagus*, *denitrificans*, *desulfuricans*, *dextranicus*, *diastaticus*, *diastatochromogenes*, *ethylicus*, *farinosus*, *felsineus*, *ferrooxidans*, *ferrugineus*, *gazogenes*, *gelaticus*, *glycinophilus*, *glycolyticus*, *halobius*, *halodenitrificans*, *halohydrius*, *halonitrificans*, *halosmophilus*, *hydrophilus*, *hydrosulfureus*, *hygroscopicus*, *indol*, *indologenes*, *indoloxidans*, *iodinum*, *iodophilus*, *iophagus*, *lactoacetophilus*, *lipoferus*, *lipolyticus*, *lipophagus*, *melaninogenicus*, *metabotulinus*, *metacaligenes*, *methanicus*, *nitritogenes*, *nitrogenes*, *nitrosus*, *oleovorans*, *oligocarbophilus*, *oxaliferus*, *oxalaticus*, *oxydans*, *pectinovorus*, *propionicus*, *proteamaculans*, *proteiformis*, *reducans*, *saccharolyticus*, *sideropous*, *suboxydans*, *succinogenes*, *sulfureus*, *sulphuricus*, *thermocellulaseus*, *thermocellus*, *thermodiastaticus*, *thiogenes*, *thiooxidans*, *thioparus*, *thiosulfatophilus*, *tyrobutyricus*, *urea*, *ureafaciens*, *ureasphorus*, *urealyticus*, *urina*.

In many cases the stems of the names of genera and of the specific epithets are from Latin or Greek. Mediaeval Latin made some contributions, but in most cases the words are Neo-Latin, formed frequently from vernacular words.

† In 1960, the late R. E. Buchanan published an essay giving the correct Latin forms of many chemical elements and compounds that may be used in forming bacteriological names and epithets (Int. Bull. Bacteriol. Nomencl. Taxon. 10:16–22, 1960). Because the essay is extremely important to all those who struggle with problems of bacteriological nomenclature, we are reprinting the article here in its entirety at the suggestion of T. O. MacAdoo, who has published recommendations on the orthography of bacterial names and who advises taxonomists on the fine points of nomenclature.

An additional reference that may be of help is available (T. O. MacAdoo, p. 339–358, in M. Goodfellow and A. G. O'Donnell, ed., *Handbook of New Bacterial Systematics*, Academic Press, 1993).

Much of the information needed for formulating new names and epithets can be found in the Neo-Latin discussed in texts on use of Latin and Greek in pharmacology. Until recent years physicians wrote their prescriptions in modern Latin, and drugs and pharmaceuticals were given Latin names. Most of the rules and conventions now used were developed with the rapid advances in pharmacology and medicine. The names and rules for their formation are still appropriate and useful. Herewith are listed some of the more important groups of the vernacular English names of chemical elements, compounds and radicals with their Latin or Neo-Latin equivalents which are available for use in coining new names of taxa in the field of microbiology.

The Latin, mediaeval Latin and Neo-Latin names of chemical elements, compounds and drugs are:

- I. (Occasionally) feminine nouns in the first declension, with nominative in *-a*.
- II. (Rarely) masculine nouns in the second declension, with nominative in *-us*.
- III. (Commonly) neuter nouns in the second declension, with nominative in *-um*.
- IV. (Some) neuter nouns in the third declension (imparisyllabic) with nominative in *-ol*, *-al*, *-er*, or *-yl*.
- V. (Some) masculine nouns in the third declension (imparisyllabic) with nominative in *-is* or *-as*.

I. Feminine nouns of first declension with nominative in *-a*, genitive *-ae*.

- a. *Names of drugs found in classical or mediaeval Latin.* There are classic or mediaeval Latin equivalents of modern names for certain drugs, as gentian = *gentiana*, *ae*, Latin feminine noun; camphor = *camphora*, *ae*, mediaeval Latin feminine noun.
- b. *Modern Latin names of drugs formed by adding -a to the vernacular name*, as ergot = *ergota*, *ae*, Neo-Latin feminine noun, from the French ergot.
- c. *Names of alkaloids and other organic bases.* These end in *-ine* in English. In Neo-Latin they are feminine nouns in the first declension and end in *-ina*.

aconitine = *aconitina*, *ae*; morphine = *morphina*, *ae*;
atropine = *atropina*, *ae*; quinine = *quinina*, *ae*;
cocaine = *cocaina*, *ae*; amine = *amina*, *ae*.

Some older pharmacopoeias give the ending *-ia* instead of *-ina*, as strychnine = *strychnia*, *ae*; morphine = *morphia*, *ae*.

- d. *Names of compounds which in the vernacular end in -a.*
urea = *urea*, *ae*.

II. Masculine nouns of second declension with nominative in *-us*, genitive *-i*.

These are not common. The name of the element phosphorus belongs here.

phosphorus = *phosphorus*, *i*.
siderus, *i* = Greek σίδηρος = iron.

III. Neuter nouns in the second declension with nominative in *-um*, genitive *-i*.

- a. *Names of chemical elements.* All except sulfur and phosphorus are neuter second declension nouns ending in *-um*. Not all end in *-um* in the vernacular. The Latin or Neo-Latin names of some of the elements that in English do not end in *-um* are here listed:

antimony = *antimonium*; arsenic = *arsenum*; bismuth = *bismuthum*; boron = *borum*; bromine = *bromum*; carbon = *carboneum* (also *carbo*, *carbinis*); chlorine = *chlorum*; cobalt = *cobaltum*; copper = *cuprum*; fluorine = *fluorum*; gold = *aurum*; hydrogen = *hydrogenum*; iodine = *iodinum*; iron = *ferrum* (see also *siderus*); lead = *plumbum*; manganese = *manganum*; mercury = *hydrargyrum*; nickel = *nicolum*; nitrogen = *nitrogenium*; (the Greek derived French azote becomes *azotum*, *i*); oxygen = *oxygenium*; potassium = *kalium*; silicon = *silicum*; silver = *argentum*; tin = *stannum*; tungsten = *wolframium*; zinc = *zincum*.

- b. *Certain "neutral principles" (of the pharmacist), which in English end in -in*, in Neo-Latin are neuter nouns of the second declension and end in *-um*, *i*.

aloin = *aloinum*, *i*; salicin = *salicinum*, *i*; saponin = *saponinum*, *i*.

- c. The names of anions which in English end in *-ide* (or *-id*) in Neo-Latin have the ending *-idum*; they are neuter nouns of the second declension.

oxide = *oxidum*; calcium oxide = *calcii oxidum*; cyanide = *cyanidum*; potassium cyanide = *potassii cyanidum*; sulfide = *sulfidum*; sodium sulfide = *sodii sulfidum*.

- d. Acid = Neo-Latin *acidum*, neuter noun of the second declension, from the Latin adjective *acidus* = sour. Acids are named by use of *acidum* followed by a descriptive neuter adjective. The corresponding English adjective usually ends in *-ous* or *-ic*, the Neo-Latin ends in *-osum*, or *-icum*.

acetic acid = *acidum aceticum*, *acidi acetici*; nitric acid = *acidum nitricum*, *acidi nitrici*; nitrous acid = *acidum nitrosus*, *acidi nitrosi*; oleic acid = *acidum oleicum*, *acidi oleici*; sulfurous acid = *acidum sulfurosus*, *acidi sulfurosi*.

- e. Chemical compounds which in English have the endings *-ane*, *-ene*, or *-one* in Neo-Latin are second declension neuter nouns ending respectively in *-anum*, *-enum*, or *-onum*.

ethane = *ethanum*, *i*; ethylene = *ethylenum*, *i*; ketone = *ketonum*, *i*; lactone = *lactonum*, *i*; propane = *propanum*, *i*.

- f. Carbohydrates (monosaccharides) usually have English names ending in *-ose*. Neo-Latin names end in *-osum* and are neuter nouns in the second declension.

cellobiose = *cellobiosum*, *i*; cellulose = *cellulosum*, *i* (occasionally *cellulosa*, *ae*); dextrose = *dextrosum*, *i*; sucrose = *sucrosum*, *i*; xylose = *xylosum*, *i*.

In general the base or combining form to be used in making names of bacterial taxa from Neo-Latin words is found by dropping the ending of the genitive singular. In a few cases the chemical usage of abbreviating this base has been followed. This may be illustrated by the treatment accorded cellulose in chemistry and bacteriology. Hydrolysis of cellulose yields, as the constituent building block of the polymer, the disaccharide names cellobiose instead of the more logically formed cellulosibiose. The shortened base *cell-* instead of *cellulos-* has been used in several bacterial generic names as *Cellvibrio* and *Cellfalcicula*.

- g. The English names of complex carbohydrates (polysaccharides with the exception of cellulose) usually end in *-an*, the name commonly derived from the name of the simple carbohydrate of which the complex is a polymer, as *dextran* from *dextrose*. The Neo-Latin equivalent is formed by adding the ending *-um*, the name being a neuter noun in the second declension.

dextran = *dextranum*, *i*; galactan = *galactanum*, *i*; xylan = *xylanum*, *i*.

- h. Organic compounds which are not alcohols whose names in English end in *-ol*, in Neo-Latin add *-um* and are neuter nouns in the second declension.

indol = *indolum*, *i*; iodol = *iodolum*, *i* (sometimes *indol*, *indolis* [see IVa]); safrol = *safrolum*, *i*.

- i. The English names of many enzymes have the ending *-ase*. The Neo-Latin equivalent ends in *-asum* and is a neuter noun of the second declension.

catalase = *catalasum*, *i*; coagulase = *coagulasum*, *i*; urease = *ureasum*, *i*.

IV. Neuter nouns in the third declension (imparisyllabic) in *-ol*, *-ur*, *-al*, *-er -yl*.

- a. The approved (standard) chemical names of alcohols in English usually end in *-ol*. Classic Latin nouns which end in *-ol* are almost nonexistent. Gradenwitz lists one only, *sol*, *solis* = the sun. In Neo-Latin the nominative of the name of an alcohol is the same as in English, and is regarded as a neuter noun ending in *-ol*, with genitive *-olis*.

alcohol = *alcohol*, *alcoholis*; citrinellol = *citrinellol*, *citrinellolis*; dulcitol = *dulcitol*, *dulcitolis*; ethanol = *ethanol*, *ethanolis*; glycerol = *glycerol*, *glycerolis*; phenol = *phenol*, *phenolis*.

Indole, though not an alcohol, has been sometimes placed here, *indole* = *indol*, *indolis*, as in *Clostridium indolis*.

- b. The name of the element sulfur* = *sulfur*, *is*, is a Latin neuter noun of the third declension. The Greek stem *thi* from *θειον* = *thium*, *i* = sulfur is also frequently used.

- c. The English names of aldehydes and of some other organic compounds end in *-al*. The nominative in Neo-Latin is the same as in English. These names are regarded as neuter nouns in the third declension. They are imparisyllabic.

acetal = *acetal*, *acetalis*; chloral = *chloral*, *chloralis*.

- d. The English names of certain organic compounds end in *-er*. The nominative in Neo-Latin is the same as in English. These names are regarded as neuter nouns in the third declension.

aether (ether) = *aether* (ether), *aetheris* (etheris); ester = *ester*, *esteris*.

- e. Organic radicals with English names ending in *-yl* have the Neo-Latin nominative as in English. They are regarded as third declension neuter nouns.

butyl = *butyl*, *butylis*; ethyl = *ethyl*, *ethylis*.

V. Names of compounds or anions that in English end in *-ite* or *-ate*. Masculine nouns of the third declension.

- a. The names of anions and compounds which in English end in *-ite* in Neo-Latin end in *-is* (genitive *-itis*).
arsenite = *arsenis*, *arsenitis*; sodium arsenite = *sodii arsenis*; nitrite = *nitris*, *nitritis*; calcium nitrite = *calcis nitris*.

- b. The names of anions and compounds which in English end in *-ate* have the Neo-Latin ending *-as*, *-atis*.
acetate = *acetas*, *acetatis*; sodium acetate = *sodii acetas*; phosphate = *phosphas*, *phosphatis*; potassium phosphate = *kalii phosphas*; *nitras*, *nitratris* (the commonly accepted combining form is *nitro*).

- c. The name of the element calcium = *calx*, *calcis*.

* The spelling approved by the American Chemical Society for the element corresponds to the classic Latin sulfur. The conventional British spelling is sulphur. This late Latin is given as an alternative spelling. *Sulphur*, *is*, is also a Latin neuter noun of the third declension.