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HISTORICAL PERSPECTIVE

Microbial Nomenclature: A List of Names and Origins

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Microbial nomenclature underwent a large number of changes in the 1970s. Many species of pathogens were added and many others experienced name changes. These modifications primarily were due to two unrelated factors: the use of new DNA hybridization techniques and the advent of computerized literature searches to establish historical precedence. In 1980 an approved list of microbial names was published. This list fixed and legitimized bacterial nomenclature. All future additions or alterations to it had to pass international scientific committees. This list has now been accepted by the scientific community. The derivation of these names are presented in this review.

In the 1970s many species names of microbial pathogens were added and many others experienced nomenclature changes (Brenner, 1983; Stafleu et al., 1972). In part, the impetus for these changes came from new molecular DNA hybridization techniques. Other changes were the result of literature searches that uncovered earlier mention of bacterial pathogens. Historical precedence required reversion to the original name. The large number of such changes caused considerable consternation for both clinicians and medical microbiologists. To establish order, an approved list of bacterial names was published in 1980 (Skerman et al.). This code legitimized the names of bacteria and established a strict scientific mechanism to institute any changes. One could no longer alter a name based on historical precedence alone. The approved list has now been accepted by the scientific community. The purpose of this review is to present the legitimate names of human pathogens and to briefly recount the procedure that resulted in the approved list and the derivation of such names.

More than 200 years ago, Linnaeus (1758) suggested a system of binomial nomenclature for animal and plants. He established the concept of taxonomy based on genus and species. The genus name denoted a cluster having major characteristics in common; a species denoted a group able to reproduce within itself, but not with other groups.

The nomenclature of pathogenic microorganisms began with the acceptance of the Germ Theory in the 1860s, and the ability in the 1880s to grow microbes in vitro and in pure culture. Unlike organisms previously classified according to Linnean concepts, pathogenic bacteria did not have a true nucleus and reproduced asexually. Separation and establishment of species status commonly was based on macroscopic

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TABLE 1. Bacterial Taxa Derived from Surnames

Genera	Named after (ref. no.)	Species	Named after (ref. no.)
Bartonella	AL Barton (73)	*beijerinckii*	MW Beijerinck (18)
Bordetella	J Bordet (54)	*boydii*	Sir John Boyd (23)
Borrelia	AE Borrel (74)	*bozemanii*	FM Bozeman (6)
Branhamella	SE Branham (13)	*burnettii*	FM Burnett (62)
Brucella	Sir David Bruce (51)	*conorii*	A Conor (8)
Coxiella	HR Cox (62)	*ducreyi*	A Ducrey (57)
Edwardsiella	PR Edwards (22)	*duttonii*	JE Dutton (60)
Escherichia	T Escherich (12)	*flexneri*	S Flexner (11)
Francisella	E Francis (19)	*freundii*	A Freund (4)
Gardnerella	HL Gardner (24)	*harveyi*	AEC Harvey (25)
Klebsiella	E Klebs (52)	*israelii*	J Israel (44)
Listeria	Lord Lister (64)	*jensenii*	S Orla-Jensen (82)
Moraxella	V Morax (49)	*lignieresii*	J Lignieres (7)
Neisseria	A Neisser (52)	*lwoffi*	A Lwoff (1)
Nocardia	E. Nocard (78)	*mazzottii*	L Mazzotti (17)
Pasteurella	L Pasteur (79)	*micdadei*	JE McDade (40)
Rickettsia	HT Ricketts (86)	*morganii*	H de R. Morgan (85)
Rochalimaea	H da Rocha-Lima (43)	*naeslundii*	C Naeslund (75)
Rothia	GC Roth (27)	*novyi*	FG Novy (52)
Salmonella	DE Salmon (52)	*parkeri*	R Parker (72)
Serratia	S Serrati (3)	*prausnitzii*	C Prausnitz (65)
Shigella	K Shiga (11)	*prowazeki*	S von Prowazek (16)
Veillonella	A Veillon (66)	*rettgeri*	LF Rettger (69)
Yersinia	AJE Yersin (81)	*rickettsiae*	HT Ricketts (63)
		russii	VR Russ (53)
		sonnei	C Sonne (45)
		sordellii	A Sordelli (36)
		stutzeri	A Stutzer (16)
		vincenti	H Vincent (74)

TABLE 2. Other Sources of Bacterial Names

Genus or Species	Literal translation or derivation
	FOODS
botulinum cepacia	A small sausage-like onion
Lactobacillus	Milk rodlet
maltophilia	Friend of malt
Staphylococcus	Grape coccus
	GEOGRAPHY
africanum	African
arizonae	Arizona
australis	"Southern"
brasiliensis	Brazil
canada	Canada

TABLE 2. (*Continued*)

Genus or Species	Literal translation or derivation
caucasica	Caucasas
Hafnia	Old name for Copenhagen
hispanica	Spain
kansasii	Kansas
melitensis	Pertaining to Malta
osloensis	Oslo
persica	Persian
siberica	Siberia
tularensis	Tulare County, California
venezuelensis	Venezuela
agalactiae	Produces bovine mastitis
akari	A mite
bovis	Of the ox
canis	Dog
chelonei	Of a tortoise
hermsii	O. hermsi (tick vector)
hominis	Of man
multocida	Many killing (pathogenic for many species)
rhusiopathiae	Of red disease (swine erysipelas)
suis	Pig
tsutsugamushi	"A small and dangerous animal" (mite vector)
turcatae	O. turcata (tick vector)
xenopei	A genus of toad (Xenopus)
	ORGANS, TISSUES OR EXCRETIONS
Cardiobacterium	Bacterium of the heart
coli	Colon
denticola	Tooth dweller
Enterobacter	Intestinal small rod
enterocolitica	Pertaining to the intestine and colon
epidermidis	Epidermidis
faecium	Of feces
faecalis	Pertaining to feces
fetus	Fetus
macrodentium	Of large teeth
orale	Oral cavity
oralis	Oral cavity
rectale	Rectum
ruminocola	Rumen
sanguis	Blood
sputorum	Lungs, bronchial tree
vaginalis	Vagina
	MISCELLANEOUS
Eubacterium	True bacterium
fortuitum	Casual, accidental
hydrophila	Water loving
Legionella	The American Legion
marcescens	"Fading away"
marinum	Marine
vulgaris	Common

parameters. The names of most microbial pathogens were published between 1870 and 1900, and are based on gross descriptive characteristics (Winslow et al., 1920; Winslow et al., 1917; Winslow et al. 1919).

Modern nomenclature was derived predominantly from directly visualized phenomena or from the names of individuals. Personal surnames have been applied in latinized form in order to memorialize the person who either discovered or described the organism first (Table 1). Often, a pathogen was named to honor an important researcher in a related field. The process of adapting names to the Linnean form occasionally has obscured the original spelling of the honored individual (e.g., McDade as *micdadei* and daRocha-Lima as *Rochalimaea*) (Vallery-Radat Pasteur, 1922). In at least one instance, the name of a person unrelated to biology was chosen. *Serratia* was named to honor Serafino Serrati because it was felt this early inventor of the steamboat concept had not received sufficient recognition (Bizio, 1823).

Geographic names (Table 2) reflect the area in which the organism was either described or found in endemic or epidemic form. Nomenclature also has been based on vector, host, and resemblance to foods or inanimate objects (Tables 2 and 3). The most clinically relevant terms were derived from a disease process or histopathologic finding (Table 4). In some instances, taxonomy is confusing because the original association of a microbial isolate with a disease subsequently has been proven incorrect. For example, *Haemophilus influenzae* initially was assumed to be the cause of influenza (Pfeiffer, 1892). Potentially confusing prefixes also have been applied to microbial names. Thus, the name "Eubacterium" implied a "true bacterium" and "Mycobacterium" denoted a "fungus-like bacterium."

Names that reflect laboratory phenomena and morphology frequently have been utilized (Table 5). Gross and microscopic morphology of the fungi (Table 6) and the parasites (Table 7) are based predominantly on the shape, texture, etc. of these organisms. Fungi and parasites generally are still identified on the basis of such criteria.

In the 1960s a concerted effort was made to conform viral nomenclature to the genus and species principle. The majority of viral names reflect disease entities (e.g., poliovirus, mumps virus) or original place of isolation (e.g., Marburg virus, Coxsackie virus). Since the widespread utilization of cell cultures, cytopathologic names have been utilized (e.g., cytomegalovirus, respiratory syncytial virus). With the exception of the Epstein–Barr virus (Epstein et al., 1964), viral taxonomy rarely has been assigned personal surnames (Table 8).

The naming of microbial pathogens has paralleled the increasing sophistication of laboratory analysis. In the late 1800s characteristics such as size, shape, color, and disease entity were utilized. Morphology remains the first step in the identification process. For example, the definition of the name *Staphylococcus aureus*, (a "golden colored cluster of grapes") is the primary step in the algorithm to identify this pathogen.

Because many species share gross similar features, the use of enzymatic biochemical tests became preeminent in the 1920s and 1930s. These tests detect a particular enzyme after growth in a defined milieu. The presence or absence of an enzyme system allowed laboratories to perform large numbers of tests on a single isolate. They could also compare results and exchange tests. Such phenotypic tests helped to overcome the inherent problem of species definition in asexual organisms by grouping pathogens based on stable, measureable characteristics. A large number of microbial isolates tested with multiple substrates could now be separated into groups. Nomenclature became a process of answering a series of "yes or no" questions, which microbiologists termed "positive" and "negative." Algorithms were developed to generate uniform identification schema. When some characteristics were found to be more important than others, various mathematical and statistical analyses were added to such decision trees (Jones and Sackin, 1980).

TABLE 3. Descriptive Bacterial Names

Genus or Species	Literal translation or derivation
RESEMBLANCE TO INANIMATE OBJECTS	
Actinobacillus	Ray rod
Arachnia	A cob web
Bacillus	A small rod
Calymmatobacterium	The sheathed rodlet
Campylobacter	A curved rod
Clostridium	A small spindle
Corynebacterium	Club bacterium
Erysipelothrix	Thread of erysipelas
Leptospira	A fine coil
Pseudomonas	False unit
Spirillum	A small spiral
Streptobacillus	A pliant small rod
Treponema	A turning thread
alvei	Of a beehive
bacilliformis	Rodlet shaped
cloacae	Of a sewer
clostridiformis	In the form of a small spindle
interrogans	Shaped like a question mark
moniliformis	Necklace shaped
Actinomyces	Ray fungus
Bifidobacterium	Cleft small rod
Chromobacterium	A colored small rod
Flavobacterium	A yellow small rod
Fusobacterium	Spindle shaped small rod
Mycobactrium	Fungus small rod
Proteus	A God able to transform to many shapes
Streptococcus	Pliant fungus
aeruginosa	Having the color verdigris (green-blue poison)
aureus	Golden
biacutus	Two pointed
bullosum	Knobbed
cereus	Wax colored
contortum	Twisted
diminuta	Minute
flavescens	Becoming yellow
furcosus	Forked
lanceolatus	Lancet shaped
minor	Smaller
mucosa	Slimy
naviforme	In the shape of a ship
nucleatum	Nucleated
pallidum	Pale
parvula	Very small
perfoetens	Very stinking
pertenue	Slender
pneumosintes	Breath destroying
preacutus	Quite sharp
putida	Stinking
ramosum	Much branched
salivarius	Slimy
sphenoides	Wedge shaped
subflava	Yellowish
tortuosum	Full of windings
ventriosum	Pot bellied
violaceum	Violet colored

TABLE 4. Bacterial Names Reflecting Disease or Histopathology

Species	Translation or derivation
abortus	Abortion
acnes	Acne, eruption
anginosus	Pertaining to angina (pharyngitis)
anthracis	Charcoal carbuncle
bronchiseptica	Infected bronchus
carateum	Bean (pinta)
catarrhalis	Flowing
cholerae	Bilious disease
dentocariosa	Decayed teeth
diphtheriae	Piece of leather
dysenteriae	Intestinal
gonorrhoeae	Effusive, effluent
granulomatis	Granuloma, granular
histolyticum	Tissue dissolving
influenzae	Influence of the stars
innoccum	Harmless
intracellulare	Intracellular
mallei	Of glanders
meningitidis	Inflammation of the meninges
meningosepticum	Associated with sepsis and meningitis
mitis	Mild
monocytogenes	Monocytosis-producing (in rabbits)
mortiferum	Death-bearing
necrophorum	Necrosis-bearing
odontolyticus	Tooth-dissolving
ozaenae	Smelling, odoriferous
perfringens	Breaking through
pestis	Pestilence
pertussis	Thoroughly
pneumoniae	Breathing
pneumophila	Lung loving
pneumotropica	Having affinity for the lungs
pseudomallei	False glanders
pseudotuberculosis	False swelling
putredinis	Putrid
quintana	Fifth (5-day fever, another name for Q fever)
recurrentis	Recurring
rhinoscleromatis	Nose destroying
scrofulaceum	Swellings
septicum	Separate
tetani	Stretched, rigid
tuberculosis	Tumor, swelling
typhi	Blind
ulcerans	Ulcer
xerosis	Dry

TABLE 5. Bacterial Name Reflecting In Vitro Behavior or Colonial Morphology

Genus or Species	Literal translation
Acidiminococcus	Amino acid coccus
Acinetobacter	Nonmotile rod
Aeromonas	Gas producing unit
Alcaligenes	Alkalai producing
Citrobacter	Citrate using rod
Haemophilus	Blood loving
Peptococcus	Digesting coccus
Peptostreptococcus	Digesting streptococcus
Plesiomonas	Neighbor unit (to be differentiated from Aeromonas)
Proprionobacterium	Proprionic acid bacterium
Vibrio	That which vibrates
acidovorans	Acid devouring
activus	Active
aerofaciens	Gas producing
aerogenes	Gas producing
alactolyticum	Nonmilk digesting
alcalescens	Alkalai making
anaerobius	Anaerobic
aphrophilus	Foam loving
asaccharolyticus	Not digesting sugar
asteroides	Star-like
avidum	Voracious
calcoaceticus	Calcium acetate (used in enrichment)
capillosus	Very hairy
coagulans	Curdling
constallatus	Studded with stars
corrodens	Gnawing
difficile	Difficult
equisimilis	Resembling Streptococcus equi
fermantans	Fermenting
fragilis	Fragile
glutinosum	Glutinous
granulosum	Granular
haemolyticus	Hemolytic
indolis	Pertaining to indole
lacunata	Pitted
lentum	Slow
limosum	Slimy
melaninogenicus	Melanin producing
nitrogenes	Nitrite producing
nonliquifaciens	Not liquifying
phenylpyruvica	Deaminates phenylalanine
pseudoalcaligines	False alkalai producing
pseudotetanicum	False tetani (resembles *Clostridium tetani*)
saprophyticus	Saprophytic
serpens	Creeping
shigelloides	*Shigella*-like (some strains share a common O antigen with *Shigella sonnei*)
sicca	Dry
Sporogenes	Spore producing
tarda	Slow (inactive)

TABLE 6. Derivation of Fungal Genus Names (15)

Genera	Translation or derivation
Aspergillus	A sprinkler
Blastomyces	Germ fungus
Candida	Dazzling white
Cladosporium	Branch seed
Coccidioides	Resembling a little berry
Cryptococcus	Hidden coccus
Epidermophyton	Outer skin plant
Fonsecaea	O Fonseca Filho
Fusarium	Spindle
Geotrichium	Earth hair
Histoplasma	Web formed
Malassezia	LC Malassez
Microsporum	Small seed
Monilia	Necklace
Mucor	Mold
Penicillium	Paint brush
Phialophora	Bowl carrier
Pityrosporium	Bran seed
Rhinosporidium	Little nose seed
Sporothrix	Seed hair
Torulopsis	Little knot form
Trichophyton	Hair plant

TABLE 7. Derivation of Parasite Taxa[a] (59)

Genera	Species	Translation or Derivation
Achanthocheilonema		Spine lip thread
Ancylostoma		Hook mouth
Angiostrongylus		Round vessle
Ascaris		Helminth
	lumbricoides	Worm-like
Babesia	*microti* Field vole (microtus)	V Babes
Balantidium		A small bag
Brugia		SL Brug
Capillaria		Hair
Chilomastix		Whip lip
	mesnili	F Mesnil
Clonorchis		Branched testis
Dicrocoelium		Double cavity
Dioctophyma		Tubercle swelling
Diphyllobothrium		Twice-leaved groove
	latum	Broad
Dipylidium		Two gate
Dirofilaria		Dreaded thread
Drancunculus		Dragon
Echinococcus		Spine berry
	granulosis	Mass of granules
Echinostoma		Spine mouth
Eimeria		T Eimer
Endolimax		Internal meadow
	nana	Dwarf
Entamoeba		Change (of shape) within
	histolytica	Tissue dissolving
Enterobius[b]		Intestinal life

TABLE 7. (Continued)

Genera	Species	Translation or Derivation
	vermicularis	Little worm
Fasciola		A fillet
Fasciolopsis		Fasciola-resembling
Giardia		A Giard
	lamblia	F Lambl
Gnathostoma		Jaw mouth
Gongylonema		Round thread
Heterophyes		Different shape
Hymenolepis		Membrane shell
	nana	Dwarf
Iodameba		Iodine amoeba
	butchlii	O Butchli
Isospora		Equal shape
	belli	F Bell
Leishmania		Sir William Leishman
	donovani	C Donovan
Loa		Native name for the parasite
Metagonimus		Posterior genitalia
	yokogawi	M Yokogawa
Mansonella		Sir Patrick Manson
Multiceps		Many headed
Necator		Killer
Onchocerca		Hook tail
	volvulus	Rolled
opisthorchis		Posterior testis
Oxyuris[b]		Sharp tail
Paragonimus		Side-by-side testis
Plasmodium		Formed material
	falciparum	Shape of a sickle
	vivax	Long-lived
	ovale	Oval
	malariae	Bad air (from disease malaria)
Pneumocystis		Lung cysts
	carinii	A Carini
Sarcocystis		Flesh bladder
Schistosoma[c]		Split body
	mansoni	Sir Patrick Manson
Strongyloides		Round-like
	stercoralis	From excrement
Syngamus		Marriage together
Taenia		Tape
Thelazia		To suck
Toxocara		Bow head
Toxoplasma		Arc
	gondii	A north African rodent (*Ctenodactylus gundi*)
Trichinella		Small hair
Trichomonas		Hair unit
Trichostrongylus		Round hair
Trichuris		Hair tail
Trypanosoma		Auger body
	cruzi	O Cruz
	brucei	J Bruce
Wuchereria		O Wucherer
	bancrofti	J Bancroft

[a]Easily defined or self-evident terms (i.e, *coli*, *americanus*, have not been included in this list.
[b]The Genus designations *Oxyuris* and *Enterobius* were both used by Linneaus (48).
[c]The term Schistosoma has priority over Bilharzia, having been published earlier

TABLE 8. Chlamydia, Mycoplasma, and Viruses

Chlamydia (58)		Mantle
	trachomatis	Rough, harsh
	psittaci	Parrot
Mycoplasma (14)		Fungus (mushroom) form
	pneumoniae	Of pneumonia
	hominis	Man, human
Ureaplasma (14)		Urea releasing
	DNA VIRUSES	
Adenovirus (28)		Adenoids
Cytomegalovirus (29)		Large cell
Herpesvirus (29)		Creeping
Papovavirus (20)		Hill, swelling
Parvovirus (28)		Small
Poxvirus (30)		Pitted (of pox diseases)
	RNA VIRUSES	
Arbovirus (31)		Arthropod borne
Arenavirus (31)		Sandy
Bunyavirus (31)		Shade
Coronavirus (32)		Crowned
Coxsackievirus (33)		Coxsackie, New York
Echovirus (33)		Enteric cytopathic human orphan
Enterovirus (33)		Enteric
Orthomyxovirus (34)		Derived from slime (mucus)
Paramyxovirus (35)		Associated with slime (mucus)
Picornavirus (33)		Small RNA
Reovirus (36)		Respiratory enteric orphan
Retrovirus (36)		Backward
Rhabdovirus (37)		Rod, mad
Rotavirus (36)		Rotary, wheel-shaped
Togavirus (31)		Covered

The measurement of phenotypic enzymatic expressions allowed the separation of major microbial pathogens into an acceptable genus and species framework, but could not be relied on to be a true standard. For example, it was found that some phenotypic expressions considered stable were not chromosomal but plasmid-mediated (e.g., the production of urease by some members of the genus *Proteus*).

In the 1970s the Centers for Disease Control applied DNA hybridization techniques to the comparison of genetic relatedness. At the end of the 1970s most of the medically important pathogens had been reanalyzed by DNA hybridization techniques. The microbiology community embarked on a program to codify the names of bacteria in order to avoid trivial, unscientific, and historical additions (Skerman et al., 1980). It had been common practice to accept the original description of a microorganism for assignment of a legitimate name. Some individuals took advantage of this regulation to search the literature in an attempt to establish historical precedence and change commonly accepted species names. Often, the original description was fragmentary and incomplete. This problem became particularly acute in the late 1970s, and threat-

ened to severely disrupt the ability of microbiologists to search the literature. In 1980 a code of bacterial nomenclature was presented (Skerman et al., 1980). This code contained all accepted names. If an organism was not in the code it could not be used for scientific purposes. The code further stipulated that, as of 1980, names would not be changed for strictly historical reasons. Any new microbial name would have to be presented to an international committee and be accepted. From 1980 to 1983 additions and changes were proposed for over 40 genera and 200 species of bacteria (Brenner, 1983). The following references are secondary references for the original authors and establish primacy: Beale, 1872; Brumpt, 1932; Bulloch, 1930; Burri and Stutzer, 1895; Chanock and Tully, 1980; Conant et al., 1971; Dulbecco, 1980; Gastinel, 1949; Ginsberg, 1980a, 1980b, 1980c, 1980d, 1980e, 1980f, 1980g, 1980h, 1980i, 1980j; Ligmeres and Spitz, 1902; Lignieres, 1900; Mazzotti, 1949; Morgan, 1906; Naeslund, 1925; Nichols and Manire, 1980; Faust and Russell, 1964; Prausnitz, 1922; Rettger, 1909; Russ, 1905; Trevisan, 1885a, 1885b.

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