Public Health Service
DEPARTMENT OF HEALTH & HUMAN SERVICES Centers for Disease Control and Prevention (CDC)

Memorandum

Date: November 14, 2002

To: State and Territorial Public Health Laboratory Directors
State and Territorial Epidemiologists

Subject: Adoption of the Kauffmann-White Scheme for designation of *Salmonella* serotypes

As you are aware, *Salmonella* serotyping has been the cornerstone for epidemiological surveillance and outbreak investigations for this important pathogen. The National *Salmonella* Surveillance system has tracked *Salmonella* isolates by serotype since 1968. New subtyping methods have come and gone, but serotyping continues to provide essential subtype information for *Salmonell*a. Even PulseNet, our state-of-the-art genotyping system for *Salmonella*, relies on accurate serotype information as the "first-tier" subtype information.

The Kauffmann-White Scheme for designation of *Salmonella* serotypes is maintained by the WHO Collaborating Centre for Reference and Research on *Salmonella* at the Institut Pasteur and is used by most of the world. The CDC uses a slightly different version of the scheme, the "Modified Kauffmann-White Scheme". A unified format for serotype designation is essential for accurate surveillance via PulseNet, Global SalmSurv, and other international networks. Therefore, to improve the accuracy of our surveillance data and to make us in-step with the rest of world with respect to *Salmonella* serotype designation, the CDC is planning to adopt the Kauffmann-White Scheme starting January 1, 2003.

The adoption of the Kauffmann-White Scheme will affect only a few of the more common serotypes (Attachment 1). The primary differences between the two schemes are:

i) *Salmonella* are divided into six subspecies that can be differentiated by biochemical and genetic tests (see Attachment 2). Under the Kauffmann-White Scheme, subspecies I serotypes are named; subspecies II through VI serotypes are identified by formula. The CDC uses names for those subspecies II through VI serotypes that were designated before 1968 and formulas for those serotypes identified after 1968. With the adoption of the Kauffmann-White scheme, all named serotypes will be subspecies I; serotypes from all other subspecies will be designated by formula. In 2000, there were four named serotypes among the top 100 serotypes that did not belong to subspecies I and will be affected by this change. *S*. Marina will be designated as *S*. IV 48:g,z_{51}:-; *S*. Flint will be designated as *S*. IV 50:z_4,z_{23}:-; *S*. Kralendyk will be designated as *S*. IV 6,7:z4,z24:-; and, *S*. Chameleon

will be designated as *S*. IV 16:z4,z32:-. To assist in the transition, we will continue to provide the old serotype name in parentheses after the formula.

ii) Under the Kauffmann-White Scheme, serogroups E2 and E3 were combined with serogroup E1. This reflects the fact that the antigenic changes in serogroups E2 and E3 are the result of lysogenic conversion by bacteriophages and thus represent minor variants of serogroup E1 serotypes. The CDC uses separate serotype names for these variants. In the future, the variants will be named as their serogroup E1 counterpart. Three serotypes in the top 100 will be affected by the merging of serogroups E2 and E3 with serogroup E1. *S*. Anatum will now include isolates previously designated as *S*. Newington; *S*. Newington will become *S*. Anatum variety (var.) 15+; and, *S*. Newbrunswick will become *S*. Give var. 15+. To assist in the transition, we will continue to provide the old serotype name in parentheses after the new name for these serotypes.

iii) Under the Kauffmann-White Scheme, what the CDC refers to as "*S*. Java" is called "*S*. Paratyphi B var. L-tartrate+" or "*S*. Paratyphi B var. Java". *S*. Paratyphi B and *S*. Java have been a source of confusion because they have the same antigenic formula (I 1,4,[5],12:b:1,2), and are differentiated only by biotype, primarily tartrate fermentation. The distinction between these two serotypes is important epidemiologically and clinically as *S*. Paratyphi B is associated with more severe, typhoid fever-like disease. With the conversion to the Kauffmann-White scheme, both biotypes will be referred to as *S*. Paratyphi B, but *S*. Java will now be known as *S*. Paratyphi B var. L-tartrate +. It is essential that the tartrate test be performed to accurately identify and report the two biotypes. To assist in the transition, we will continue to provide "*S*. Java" in parentheses after the new name for this serotype.

With the adoption of the Kauffmann-White scheme, the CDC will also change the way that isolates that are not fully serotyped are designated in the Public Health Laboratory Information System (PHLIS). Currently, these isolates are reported primarily by serogroup. While serogroups A through E are composed mainly of subspecies I serotypes, many of the other O serogroups are represented in several different subspecies. Most of the serogroups higher than E include serotypes from more than one subspecies, and nearly half (15 of 37) include serotypes from five different subspecies. Reporting isolates by serogroup alone combines unrelated isolates of different subspecies in the same serogroup category. Starting January 1, 2003, the "serogroup" categories will no longer be used in PHLIS. When full serotype information is not available, isolates will be identified first by subspecies, then O serogroup and any additional serotype antigens. We hope that this change will improve our surveillance for the less common serotypes, particularly those belonging to subspecies II through VI. When full serotype information is not available, we encourage you to include all available information in your PHLIS submission (subspecies, O serogroup, O antigens, H antigens, whether one or two H antigens are detected, rough or mucoid status if appropriate) so that the most accurate designations can be recorded.

Several resources may assist you as we make this transition. Attached is a brief tutorial on *Salmonella* serotype designation that you may find helpful during the conversion to the Kauffmann-White Scheme (Attachment 2). Also attached is a list of the old and new designations for all serotypes currently in the National *Salmonella* Surveillance database that will be affected by the change (Attachment 1). The old serotype designation will be included in parentheses after the new designation in the PHLIS reporting system picklist of serotypes and in future reports until the transition has been made. We are establishing a website that will present the new and old schemes as well as allow you to search for serotype designation based on any part of the formula or the old or new name. It will be located at http://www.cdc.gov/ncidod/dbmd/foodborne/index.htm. A listserv is available for discussion of topics related to *Salmonella* serotyping. To subscribe, contact Linda Gheesling [llg1@cdc.gov]. Please feel free to contact Dr. Patricia Fields [pif1@cdc.gov, (404) 639-1748] if you have any questions regarding *Salmonella* serotype designations.

Sincerely,

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Attachment 1. Changes in *Salmonella* Serotype Designations
Attachment 2. Overview of *Salmonella* Serotype Designation

Attachment 1. Changes in *Salmonella S* erotype Designations[1]

Serotype (old)	Serotype (new)	# isolates 1991-2000[2]	Ssp	O Group	O antigen	H antigen Phase 1	H antigen Phase 2
Acres	S. II 13,23:b:[1,5]:z42 (formerly Acres)	1	II	O:13 (G)	1,13,23	b	[1,5]
Angola	S. II 9,12:z:z6	0	II	O:9 (D1)	1,9,12	z	z6
Ardwick	Rissen var. 14+	0	I	O:7 (C1)	6,7,14	f,g	-
Argentina	S. IV 6,7:z36:- (formerly Argentina)	1	IV	O:7 (C1)	6,7	z36	-
Arkansas	Muenster var 15+, 34+ (formerly Arkansas)	16	I	O:3,10 (E1)	3,15,34	e,h	1,5
Baragwanath	S. II 6,8:m,t:1,5	0	II	O:8 (C2)	6,8	m,t	1,5
Beloha	S. II 18:z36:-	0	II	O:18 (K)	18	z36	-
Bern	S. IV 40:z4,z32:- (formerly Bern)	4	IV	O:40 (R)	1,40	z4,z32	-
Binza	Orion var. 15+ (formerly Binza)	12	I	O:3,10 (E1)	3,15	y	1,5
Bleadon	S. II 17:g,t:[e,n,x,z15] (formerly Bleadon)	1	II	O:17 (J)	17	g,t	[e,n,x,z15]
Bonaire	S. IV 50:z4,z32:- (formerly Bonaire)	5	IV	O:50 (Z)	50	z4,z32	-
Bongor	S. V 48:z35:- (formerly Bongor)	3	V	O:48 (Y)	48	z35	-
Bornum	Lille var. 14+ (formerly Bornum)	2	I	O:7 (C1)	6,7,14	z38	-
Cambridge	Meleagridis var. 15+ (formerly Cambridge)	2	I	O:3,10 (E1)	3,15	e,h	l,w
Canastel	S. II 9,12:z29:1,5	0	II	O:9 (D1)	9,12	z29	1,5
Canoga	Westhampton var. 15+, 34+ (formerly Canoga)	31	I	O:3,10 (E1)	3,15,34	g,s,t	-
Chameleon	S. IV 16:z4,z32:- (formerly Chameleon)	77	IV	O:16 (I)	16	z4,z32	-
Chersina	S. II 47:z:z6	0	II	O:47 (X)	47	z	z6
Chudleigh	S. II 3,10:e,n,x:1,7	0	II	O:3,10 (E1)	3,10	e,n,x	1,7
Clifton	S. II 13,22:z29:1,5	0	II	O:13 (G)	13,22	z29	1,5
Daressalaam	S. II 9,12:l,w:e,n,x	0	II	O:9 (D1)	1,9,12	l,w	e,n,x
Decatur	Choleraesuis var. Decatur (formerly Decatur)	7	I	O:7 (C1)	6,7	c	1,5
Degania	S. II 40:z4,z24:z39 (formerly Degania)	2	II	O:40 (R)	40	z4,z24	z39
Drypool	Amsterdam var. 15+ (formerly Drypool)	45	I	O:3,10 (E1)	3,15	g,m,s	-
Duivenhoks	S. II 9,46:g,[m],[s],t:[e,n,x] (formerly Duivenhoks)	1	II	O:9,46 (D2)	9,46	g,[m],[s],t	[e,n,x]
Durbanville	S. II 4,12,27:z39:1,[5],7	0	II	O:4 (B)	1,4,12,27	z39	1,[5],7
Eimsbuettel	Livingstone var. 14+ (formerly Eimsbuettel)	1	I	O:7 (C1)	6,7,14	d	l,w
Erlangen	S. II 48:g,m,t:- (formerly Erlangen)	2	II	O:48 (Y)	48	g,m,t	-
Ferlac	S. VI 6,14,25:a:e,n,x	0	VI	O:6,14 (H)	1,6,14,25	a	e,n,x
Flint	S. IV 50:z4,z23:- (formerly Flint)	402	IV	O:50 (Z)	50	z4,z23	-
Fremantle	S. II 42:g,t:- (formerly Fremantle)	1	II	O:42 (T)	42	g,t	-
Goerlitz	Vejle var. 15+	0	I	O:3,10 (E1)	3,15	e,h	1,2
Goodwood	S. II 13,22:z29:e,n,x	0	II	O:13 (G)	13,22	z29	e,n,x
Haddon	S. II 16:z4,z23:- (formerly Haddon)	1	II	O:16 (I)	16	z4,z23	-
Hagenbeck	S. II 48:d:z6 (formerly Hagenbeck)	9	II	O:48 (Y)	48	d	z6
Halmstad	Westhampton var. 15+ (formerly Halmstad)	7	I	O:3,10 (E1)	3,15	g,s,t	-
Hamburg	S. II 9,12:g,m,[s],t:[1,5,7]:[z42] (includes Hamburg)	8	II	O:9 (D1)	1,9,12	g,t	-
Harmelen	S. IV 51:z4,z23:-	0	IV	O:51	51	z4,z23	-
Heilbron	S. II 6,7:l,z28:1,5:[z42] (formerly Heilbron)	5	II	O:7 (C1)	6,7	l,z28	1,5

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Serotype (old)	Serotype (new)	# isolates 1991-2000[2]	Ssp	O Group	O antigen	H antigen Phase 1	H antigen Phase 2
Heves	Finkenwerder (includes Heves)	1	I	O:6,14 (H)	[1],6,14,[25]	d	1,5
Hillbrow	S. II 17:b:e,n,x,z15	0	II	O:17 (J)	17	b	e,n,x,z15
Houten	S. IV 43:z4,z23:- (formerly Houten)	60	IV	O:43 (U)	43	z4,z23	-
Illinois	Lexington var. 15+, 34+ (formerly Illinois)	2	I	O:3,10 (E1)	3,15,34	z10	1,5
Islington	S. II 3,10:g,t:- (formerly Islington)	1	II	O:3,10 (E1)	3,10	g,t	-
Jacksonville	S. II 16:z29:e,n,x	0	II	O:16 (I)	16	z29	e,n,x
Java	Paratyphi B var. L(+) tartrate+ (formerly Java)	2389	I	O:4 (B)	1,4,5,12	b	1,2
Kilwa	S. II 4,12:l,w:e,n,x (formerly Kilwa)	25	II	O:4 (B)	4,12	l,w	e,n,x
Kinshasa	Uganda var. 15+ (formerly Kinshasa)	26	I	O:3,10 (E1)	3,15	l,z13	1,5
Kralendyk	S. IV 6,7:z4,z24:- (formerly Kralendyk)	76	IV	O:7 (C1)	6,7	z4,z24	-
Kuilsrivier	S. II 9,12:g,m,s,t:e,n,x	0	II	O:9 (D1)	1,9,12	g,m,s,t	e,n,x
Lanka	Weltevreden var. 15+ (formerly Lanka)	8	I	O:3,10 (E1)	3,15	r	z6
Lichtenberg	S. II 41:z10:z6 (formerly Lichtenberg)	2	II	O:41 (S)	41	z10	z6
Limbe	S. II 13,22:g,m,t:[1,5] (formerly Limbe)	3	II	O:13 (G)	1,13,22	g,m,t	[1,5]
Lincoln	S. II 11:m,t:e,n,x (formerly Lincoln)	1	II	O:11 (F)	11	m,t	e,n,x
Lohbruegge	S. IV 44:z4,z32:- (formerly Lohbruegge)	9	IV	O:44 (V)	44	z4,z32	-
Luanshya	S. II 13,23:g,m,[s],t:[e,n,x] (formerly Luanshya)	1	II	O:13 (G)	1,13,23	g,m,[s],t	[e,n,x]
Maarssen	S. II 9,46:z4,z24:z39:z42 (formerly Maarssen)	1	II	O:9,46 (D2)	9,46	z4,z24	z39
Makumira	S. II 4,12,27:e,n,x:1,[5],7 (formerly Makumira)	1	II	O:4 (B)	1,4,12,27	e,n,x	1,[5],7
Manila	Lexington var. 15+ (formerly Manila)	2	I	O:3,10 (E1)	3,15	z10	1,5
Marina	S. IV 48:g,z51:- (formerly Marina)	434	IV	O:48 (Y)	48	g,z51	-
Matroosfontein	S. II 3,10:a:e,n,x	0	II	O:3,10 (E1)	3,10	a	e,n,x
Menhaden	Give var. 15+, 34+ (formerly Menhaden)	28	I	O:3,10 (E1)	3,15,34	l,v	1,7
Minneapolis	Anatum var. 15+, 34+ (formerly Minneapolis)	13	I	O:3,10 (E1)	3,15,34	e,h	1,6
Mjimwema	S. II 9,12:b:e,n,x	0	II	O:9 (D1)	1,9,12	b	e,n,x
Mobeni	S. II 16:g,[m],[s],t:e,n,x	0	II	O:16 (I)	16	g,[m],[s],t	e,n,x
Muizenberg	II 9,12:g,m,[s],t:[1,5,7]:[z42]	0	II	O:9 (D1)	9,12	g,m,s,t	1,5
Mundsburg	S. IV 11:g,z51:- (formerly Mundsburg)	1	IV	O:11 (F)	11	g,z51	-
Nachshonim	S. II 13,23:z:1,5 (formerly Nachshonim)	2	II	O:13 (G)	1,13,23	z	1,5
Nancy	Nchanga var. 15+	0	I	O:3,10 (E1)	3,15	l,v	1,2
Negev	S. II 41:z10:1,2 (formerly Negev)	2	II	O:41 (S)	41	z10	1,2
Newbrunswick	Give var. 15+ (formerly Newbrunswick)	159	I	O:3,10 (E1)	3,15	l,v	1,7
Newhaw	Muenster var. 15+ (formerly Newhaw)	7	I	O:3,10 (E1)	3,15	e,h	1,5
Newington	Anatum var. 15+ (formerly Newington)	188	I	O:3,10 (E1)	3,15	e,h	1,6
Nienstedten	Ohio var. 14+ (formerly Nienstedten)	6	I	O:7 (C1)	6,7,14	b	l,w
Noordhoek	S. II 16:l,w:z6 (formerly Noordhoek)	1	II	O:16 (I)	16	l,w	z6
Nordenham	S. II 4,12,27:z:e,n,x (formerly Nordenham)	1	II	O:4 (B)	1,4,12,27	z	e,n,x
Ochsenzoll	S. IV 16:z4,z23:- (formerly Ochsenzoll)	3	IV	O:16 (I)	16	z4,z23	-
Omderman	Amersfoort var. 14+	0	I	O:7 (C1)	6,7,14	d	e,n,x

Attachment 1. Changes in *Salmonella S* erotype Designations[1]

Serotype (old)	Serotype (new)	# isolates 1991-2000[2]	Ssp	O Group	O antigen	H antigen Phase 1	H antigen Phase 2
Parera	S. IV 11:z4,z23:- (formerly Parera)	30	IV	O:11 (F)	11	z4,z23	-
Phoenix	S. II 47:b:1,5 (formerly Phoenix)	51	II	O:47 (X)	47	b	1,5
Portsmouth	London var. 15+ (formerly Portsmouth)	15	I	O:3,10 (E1)	3,15	l,v	1,6
Pullorum	Gallinarum (includes Pullorum)	2	I	O:9 (D1)	1,9,12	-	-
Quimbamba	S. II 47:d:z39 (formerly Quimbamba)	5	II	O:47 (X)	47	d	z39
Rhodesiense	S. II 9,12:d:e,n,x	0	II	O:9 (D1)	9,12	d	e,n,x
Rosenthal	Butantan var 15+ (formerly Rosenthal)	1	I	O:3,10 (E1)	3,15	b	1,5
Roterberg	S. IV 6,7:z4,z23:- (formerly Roterberg)	8	IV	O:7 (C1)	6,7	z4,z23	-
Sachsenwald	S. IV 40:z4,z23:-	0	IV	O:40 (R)	1,40	z4,z23	-
Sakaraha	S. II 48:k:z39 (formerly Sakaraha)	1	II	O:48 (Y)	48	k	z39
Salinatis	Duisberg (includes Salinatis)	13	I	O:4 (B)	4,12	d	e,n,z15
Selandia	Nyborg var. 15+ (formerly Selandia)	1	I	O:3,10 (E1)	3,15	e,h	1,7
Seminole	S. IV 40:g,z51:- (formerly Seminole)	1	IV	O:40 (R)	1,40	g,z51	-
Setubal	S. II 60:g,m,t:z6 (formerly Setubal)	1	II	O:60	60	g,m,t	z6
Soesterberg	S. IV 21:z4,z23:- (formerly Soesterberg)	2	IV	O:21 (L)	21	z4,z23	-
Sofia	S. II 4,12,27:b:[e,n,x] (formerly Sofia)	1	II	O:4 (B)	1,4,12,27	b	[e,n,x]
Springs	S. II 40:a:z39	0	II	O:40 (R)	40	a	z39
Stevenage	S. II 13,23:[z42]:1,[5],7	0	II	O:13 (G)	1,13,23	[z42]	1,[5],7
Stikland	S. II 3,10:m,t:e,n,x (formerly Stikland)	1	II	O:3,10 (E1)	3,10	m,t	e,n,x
Suarez	S. II 40:c:e,n,x,z15 (formerly Suarez)	1	II	O:40 (R)	1,40	c	e,n,x,z15
Thielallee	Oranienburg var. 14+	0	I	O:7 (C1)	6,7,14	m,t	-
Thomasville	Orion var. 15+, 34+ (formerly Thomasville)	19	I	O:3,10 (E1)	3,15,34	y	1,5
Tosamanga	S. II 6,7:z:1,5	0	II	O:7 (C1)	6,7	z	1,5
Tournai	Stockholm var. 15+	0	I	O:3,10 (E1)	3,15	y	z6
Tuebingen	Amager var. 15+	0	I	O:3,10 (E1)	3,15	y	1,2
Tuindorp	S. IV 43:z4,z32:- (formerly Tuindorp)	7	IV	O:43 (U)	43	z4,z32	-
Tygerberg	S. II 13,23:a:z42 (formerly Tygerberg)	4	II	O:13 (G)	1,13,23	a	z42
Uphill	S. II 42:b:e,n,x,z15 (formerly Uphill)	1	II	O:42 (T)	42	b	e,n,x,z15
Volksdorf	S. IV 43:z36,z38:- (formerly Volksdorf)	5	IV	O:43 (U)	43	z36,z38	-
Wandsbek	S. II 21:z10:[z6] (formerly Wandsbek)	1	II	O:21 (L)	21	z10	[z6]
Wassenaar	S. IV 50:g,z51:- (formerly Wassenaar)	131	IV	O:50 (Z)	50	g,z51	-
Worcester	S. II 13,23:m,t:e,n,x	0	II	O:13 (G)	1,13,23	m,t	e,n,x
Wynberg	S. II 9,12:z39:1,7 (formerly Wynberg)	2	II	O:9 (D1)	1,9,12	z39	1,7

[1] Serotype designations that have not changed are not listed. Includes only those serotypes with at least one isolate in the National *Salmonella* Surveillance database (1968-2000), n=111.

[2] Number of isolates reported in the National Salmonella Surveillance System 1991-2000. Greater than about 100 isolates in this time period indicates a "top 100" serotype. Top 100 serotypes represent approximately 98% of clinical isolates.

Attachment 2. Overview of *Salmonella* Serotype Designation

1) *Salmonella* Taxonomy[1]

The **genus *Salmonella*** divided into two species, *Salmonella enterica* and *Salmonella bongori.*

Salmonella enterica is further subdivided into 6 subspecies that are designated by names or Roman numerals. The Roman numerals are simpler and more commonly used. Subspecies IIIa and IIIb were historically considered a separate genus, ***Arizonae***, and are still sometimes referred to by this name.

***Salmonella enterica* subspecies**	
I	*enterica*
II	*salamae*
IIIa	*arizonae*
IIIb	*diarizonae*
IV	*houtenae*
VI	*indica*

Salmonella bongori was originally designated *S. enterica* **subspecies V**. It has since been determined to be a separate species of *Salmonella*. However, for simplicity and convenience, these strains are commonly referred to as "subspecies V" for the purpose of serotype designation.

2) *Salmonella* Serotype Antigens

Salmonella serotype is based on the immunoreactivity of two surface structures, **O antigen** and **H antigen.**

O antigen is a carbohydrate antigen (also called a polysaccharide) that is the outermost component of LPS (lipopolysaccharide). It is a polymer of **O subunits**; each O subunit is typically composed of four to six sugars depending on the O antigen. Variation in O antigen results from variation in the sugar components of the O subunit, from variation in the nature of the covalent bond between the sugars of the subunit, and from variation in the nature of the linkage between the O subunits that form the O antigen polymer.

O antigens are designated by numbers and are divided into **O serogroups** or **O groups**. O groups are designated by the primary **O factor(s)** that are associated with the group. Many of the common O groups were originally designated by letter and are still commonly referred to by letter (e.g., *S*. Typhimurium belongs to Group O:4 or Group B, *S*. Enteritidis belongs to group O:9 or Group D1; *S*. Paratyphi A belongs to Group O:2 or Group A).

Additional O factors are associated with some O groups and are often variably present or variably expressed. Table 1 lists the O groups and the additional O antigens that may be present in serotypes of that group. When multiple O factors are present, they are listed sequentially and separated by commas.

H antigen is a protein antigen called flagellin; multiple flagellin subunits make up the filament component of the flagella. The ends of flagellin are conserved and give the flagella its

characteristic filament structure. The antigenically variable portion of flagellin is the middle region, which is surface-exposed. *Salmonella* is unique among the enteric bacteria in that it can express two different flagellin antigens. Typically, this is coordinated so that only one antigen is expressed at time in a single bacterial cell. The two antigens are referred as Phase 1 and Phase 2. "**Monophasic**" isolates are those that express only a single flagellin type. These occur naturally in some serotypes (e.g., *S.* Enteritidis, *S*. Typhi, most subspecies IIIa and IV serotypes), or can occur through the inactivation of the gene encoding the Phase 1 or Phase 2 antigen.

Table 2 lists the H antigens of *Salmonella*. Some antigens are composed of multiple **factors**, which are separated by commas; for example, the second phase antigen of S. Typhimurium is composed of factors 1 and 2, which is represented as "1,2". Related antigens are grouped into **complexes**.

3) *Salmonella* Serotype Identification

Salmonella serotypes are typically identified in a cascade of tests. First, an isolate is identified and the subspecies is determined, typically by biochemical testing. O antigens and H antigens are detected in independent agglutination assays using antisera that react with groups of related antigens or a single antigen. Both H antigens can sometimes be detected in a single culture, particularly for older strains or for isolates that have been passed multiple times. When only one H antigen is detected, the isolate is inoculated onto the top of a tube of **phase reversal media**, a semisolid media containing antisera to the H antigen that has already been identified. Organisms expressing the previously detected H antigen are immobilized by the added antisera and grow only at the top of the tube. Organisms expressing the second H antigen are able to move away from the top of tube, evidenced by growth throughout the tube. The second H antigen is then determined using organisms recovered from the bottom of the phase reversal media.

4) *Salmonella* Serotype Designation

All *Salmonella* serotypes can be designated by a formula. Additionally, subspecies I serotypes are given a name (e.g., Typhimurium, Enteritidis, Typhi, etc).

The typical format for a serotype formula is:

Subspecies [space] O antigens [colon] Phase 1 H antigen [colon] Phase 2 H antigen

Examples:

I 4,5,12:i:1,2 (*S*. Typhimurium)
I 4,12:i:1,2 (*S*. Typhimurium)
I 9,12:g,m:- (*S*. Enteritidis)
II 47:b:1,5 (*S*. II 47:b:1,5)
IV 48:g,z_{51}:- (*S*. IV 48:g,z_{51}:-)
IIIb 65:(k):z (*S*. IIIb 65:(k):z)

Other conventions:

* Some O and H factors are variably present. This is indicated in the generic serotype formula by underline when the factor is encoded on a bacteriophage (e.g., 1) or by square brackets (e.g., [5]) when the antigen is variably present. For an individual isolate, if the variable factor is

detected it is included in the formula without additional notation. If the variable factor is not detected, it is not listed in the formula. Weakly recognized antigens are indicated by parentheses (e.g., (k)).

* The absence of an H antigen is indicated by a minus sign ("-") for the particular phase. For example, the "monophasic Group B" isolates that are becoming more common in the US are designated as "*S.* I 4,5,12:i:- " or "*S.* I 4,12:i:- ". Nonmotile isolates (express no H antigen) are indicated by minus signs in both phases, but can also be designated by "NM" or "nonmotile" in place of the H antigens.
* Isolates that do not express O antigen (rough isolates) or express a capsule that prevents immunologic detection of the O antigen (mucoid isolates) are indicated by "O-rough" or "Mucoid" in place of the O antigen.
* Rarely, isolates express a third H antigen that is noted by a colon followed by the antigen after the Phase 2 H antigen (e.g., *S.* II 13,23:b:[1,5]:z42, formerly *S.* Acres)

5) *Salmonella* Serotype Statistics

There were 2501 *Salmonella* serotypes as of 2001; approximately 60% belong to subspecies I. In the US, approximately 99% of reported human isolates belong to subspecies I. The "top 10" serotypes account for approximately 74% of all isolates reported in the US; the "top 100" serotypes account for about 98% of all isolates. Among the top 100 serotypes, only *S.* IV 48:g,z51:- (formerly *S.* Marina), *S.* IV 50:z4,z23:- (formerly *S.* Flint), *S.* IV 6,7:z4,z24:- (formerly *S.* Kralendyk), and *S.* IV 16:z4,z32:- (formerly *S.* Chameleon) are not subspecies I. Among the non-subspecies I isolates, subspecies IV isolates are the most common, followed by subspecies II, IIIa, and IIIb. Subspecies VI and *S. bongori* isolates are very rare.

6) Additional Reading

Brenner, F. W., R. G. Villar, F. J. Angulo, R. Tauxe, and B. Swaminathan.. 2000. *Salmonella* nomenclature. J Clin Microbiol 38: 2465-2467 [http://jcm.asm.org/cgi/reprint/38/7/2465.pdf]

Brenner, F. W., and A. C. McWhorter-Murlin. 1998. Identification and Serotyping of *Salmonella*. Centers for Disease Control and Prevention, Atlanta, GA.

Popoff, M. Y. 2001. Antigenic Formulas of the *Salmonella* Serovars, 8th edition. WHO Collaborating Centre for Reference and Research on *Salmonella*, Pasteur Institute, Paris, France.

Popoff, M. Y., J. Bockemuhl, F. W. Brenner, and L. L. Gheesling. 2001. Supplement 2000 (no. 44) to the Kauffmann-White scheme. Res. Microbiol. 152:907-909.

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[1] According to the Bacteriological Code, the legitimate species name for S. *enterica* is *S. choleraesuis*, and there are a few other differences from the nomenclature described. The official taxonomic designations are confusing and proposals to change them are currently under consideration. The taxonomy described here is used by most laboratories worldwide, including the CDC.

Table 1. Antigens associated with *Salmonella* O serogroups

O Group (number designation)	O Group (letter designation)	Antigens present in all serotypes	Additional antigens that may be present in some serotypes
2	A	2,12	1
4	B	4,12	1; 5; 27
7	C1	6,7	14; (Vi)
8	C2	8	6; 20
9	D1	9,12	1; (Vi)
9,46	D2	9,46	none
9,46,27	D3	9,12,46,27	1
3,10	E1	3,10	15; 15,34
1,3,19	E4	1,3,19	10; 15
11	F	11	none
13	G	13	1; 22; 23
6,14	H	6,14	1; 24; 25
16	I	16	none
17	J	17	none
18	K	18	6; 14
21	L	21	none
28	M	28	none
30	N	30	none
35	O	35	none
38	P	38	none
39	Q	39	none
40	R	40	1
41	S	41	none
42	T	42	1
43	U	43	none
44	V	44	1
45	W	45	none
47	X	47	1
48	Y	48	none
50	Z	50	none
51		51	1
52		52	none
53		53	1
54 (provisional)		54	21; 3; 3,15; 4,12; 8,20; 6,7
55		55	none
56		56	none
57		57	none
58		58	none
59		59	1
60		60	none
61		61	none
62		62	none
63		63	none
65		65	none
66		66	none
67		67	none

Table 2. H (flagellar) antigens of *Salmonella*

1 complex:	1,2	Other antigens (not part of a complex):	a
	1,5		b
	1,6		c
	1,7		d
	1,2,5		e,h
	1,2,7		i
	1,5,7		k
	1,6,7		(k)
EN complex:	e,n,x		r
	e,n,x,z15		r,i
	e,n,z15		y
G complex:	f,g		z
	f,g,m,t		z6
	f,g,s		z10
	f,g,t		z29
	g,m		z35
	g,m,p,s		z36
	g,m,q		z36,z38
	g,m,s		z38
	g,m,s,t		z39
	g,m,t		z41
	g,p		z42
	g,p,s		z44
	g,p,u		z47
	g,q		z50
	g,s,q		z52
	g,s,t		z53
	g,t		z54
	g,z51		z55
	g,z62		z56
	g,z63		z57
	g,z85		z60
	m,p,t,u		z61
	m,t		z64
L complex:	l,v		z65
	l,w		z67
	l,z13		z68
	l,z13,z28		z69
	l,z28		z71
Z4 complex:	z4,z23		z81
	z4,z23,z32		z83
	z4,z24		z87
	z4,z32		z88