

Current Comments

The 1,000 Most-Cited Contemporary Authors. Part 2C. Details on Authors in Hematology, Histology, Immunology, Microbiology, Physiology, and Virology

Number 22

May 31, 1982

This essay is the fourth part of our study of the 1,000 most-cited contemporary scientists. The study is based on data for articles published by these authors from 1965 to 1978—that's why we call them "contemporary." Citation data on these articles were taken from journals indexed in *Science Citation Index*[®] (*SCI*[®]). We did *not* count citations to books. The citation counts reflect "all-author" data—that is, each author was treated as a first author, whether or not his or her name appeared first in an article's by-line.

In Part 1 of this series, we provided the entire list of 1,000 authors.¹ That was followed by Part 2A which presented citation and authorship data on 214 scientists in the physical and chemical sciences: aeronomy, astronomy, astrophysics, geophysics, physics, chemical physics, physical chemistry, inorganic chemistry, organic chemistry, organometallic chemistry, analytical chemistry, and theoretical chemistry.²

Part 2B covered 267 authors in seven life sciences fields: biochemistry, biophysics, cell biology, enzymology, genetics, molecular biology, and plant sciences.³ This part covers 238 authors in six additional life sciences that are more clinically oriented. The next part will cover 13 even more clinically oriented fields listed at the end of this essay.

As you can see, modern science is a very specialized enterprise. This is espe-

cially true of the life sciences—a total of 26 life sciences disciplines will be covered in this study. In order to avoid mistaken classifications, we decided to have the authors in this study tell us under what disciplines they should be placed. We did this by providing a questionnaire which included a list of specialties which each author simply checked off. However, some of them checked as many as five separate specialties. In these cases, we examined their papers, institutional affiliations, academy memberships, and other indicators to decide on the most appropriate "pigeonhole."

Table 1 lists the names of the 238 authors who were classified as immunologists, virologists, microbiologists, physiologists, histologists, or hematologists. The names are arranged in alphabetical order under the appropriate specialty headings in order to avoid spurious comparisons between individual citation counts. Remember that 1,000 authors represent only .2 percent of an estimated 500,000 scientists publishing worldwide. Although almost all of the 1,000 most-cited authors are of *Nobel class*,⁴ many more authors not shown on these lists are equally eminent. A world academy of sciences would probably accommodate from 2,000 to 5,000 members.

Table 1 provides counts of citations and *cited* papers for each author. These totals are "disaggregated" to show the number of citations received, and the

Table 1: The most-cited scientists in the preclinical basic sciences (second group), listed alphabetically by fields. Date of birth is in parentheses. A = total citations. B = first author citations. C = citations as a secondary author. D = total number of cited papers. E = first author papers. F = secondary-authored papers. G = citations/paper. Academy memberships are indicated by a code in column H. A key to these codes appears in Table 2. Asterisks indicate Nobel prizewinners.

	A	B	C	D	E	F	G	H		A	B	C	D	E	F	G	H	
Immunology									Immunology									
									(cont.)									
ALLISON AC (1925)	6846	3456	3390	193	75	118	35		KLEBANOFF SJ (1927)	2476	1666	810	56	22	34	44		
ALPER CA (1931)	2918	1670	1248	88	39	49	33		KLEIN E (1925)	3910	579	3331	172	22	150	22		
AMOS DB (1923)	2958	886	2072	122	28	94	24		KLEIN G (1925)	10347	3360	6987	387	111	276	26	ABDI	
AOKI T (1930)	2854	1037	1812	58	27	31	49		KUNKEL HG (1916)	9134	556	8578	168	17	151	54	ABE I	
ASKONAS BA (1923)	2542	920	1622	55	22	33	46	C	LAURELL CB (1919)	4283	3417	866	63	33	30	67	F I	
ASOFSKY R (1933)	2598	64	2534	81	5	76	32		LEDERER E (1908)	2670	187	2483	131	9	122	20	FitA	
AUSTEN KF (1928)	8538	368	8170	271	13	258	31	AB	LEVINE L (1924)	4223	727	3496	195	45	150	21		
AVRAMEAS S (1930)	4717	3017	1700	113	30	83	41		LICHTENSTEIN LM (1934)	3955	1483	2472	166	44	121	23		
BACH FH (1934)	4975	2076	2899	154	44	110	32		MACKANESS GB (1922)	3078	1599	1479	49	17	32	62	BC	
BACH JF (1940)	2806	2149	657	139	73	66	20	U	MACKAY IR (1922)	3330	803	2527	148	29	119	22		
BASTEN A (1939)	2790	1580	1210	41	15	26	68		MARCHALONIS JJ (1940)	2733	1876	857	77	32	45	35		
BENACERRAF B (1920) *	8694	1071	7623	242	25	217	35	AB	MCDEVITT HO (1930)	4366	1668	2698	97	20	77	45	A	
BIANCO C (1941)	2644	1197	1447	28	11	17	94		MERGENHAGEN SE (1930)	3188	298	2890	95	12	83	33		
BLANDEN RV (1938)	2463	1158	1305	51	20	31	48	H	MERRILL JP (1917)	5229	252	4977	203	20	183	25	B	
BLOCH KJ (1929)	2931	578	2353	116	15	101	25		MICKEY MR (1923)	3127	25	3102	93	3	90	33		
BORSOS T (1927)	3404	866	2538	124	15	109	27		MILLER JFAP (1931)	6562	2802	3760	100	41	59	65	ACH	
BOYSE EA (1923)	10159	1563	8596	174	22	152	58	ABC	MILSTEIN C (1927)	3130	1315	1815	87	24	63	35	AC	
BRUNNER KT (1918)	2917	1032	1885	44	7	37	66		MÖLLER G (1936)	5315	1937	3378	126	49	77	41		
CANTOR H (1942)	2508	1922	586	47	24	23	53		MULLER EBERHARD HJ (1927)	7579	1260	6319	157	13	144	48	A	
CEROTTINI JC (1938)	3103	1226	1877	64	25	39	48		NAJARIAN JS (1927)	3446	444	3002	301	21	280	11		
CLAMAN HN (1930)	3076	1597	1479	83	32	51	37		NATVIG JB (1934)	2726	587	2139	136	33	103	20		
COCHRANE CG (1930)	3848	1348	2500	89	21	68	43		NOSSAL GJV (1931)	3409	1712	1697	79	41	38	43	ABHZ	
COHN M (1922)	2749	239	2510	72	23	49	38		NUSSENZWEIG V (1928)	3957	745	3712	66	11	55	59		
COOPER MD (1933)	5774	2133	3641	162	43	119	35		OPPENHEIM JJ (1934)	3631	1535	2096	87	27	60	41		
DAUSSET J (1916) *	2861	1044	1817	203	69	134	14	AU	PARKER CW (1930)	3896	803	3093	162	32	130	24		
DAVID JR (1930)	4243	1544	2699	102	26	76	41	B	PARKS WP (1941)	2568	940	1628	71	25	46	36		
DIXON FJ (1920)	7456	623	6833	161	16	145	46	A	PAUL WE (1936)	6082	685	5397	145	25	120	41	A	

**Immunology
(cont.)**

	A	B	C	D	E	F	G	H
DOUGLAS SD (1939)	3098	993	2105	132	46	86	73	
DRAY S (1920)	2764	53	2711	131	5	276	21	
DUTTON RW (1930)	3568	976	2592	61	19	43	58	
EDELMAN GM (1929) *	7975	2566	5409	139	24	115	57 AB	
FAHEY JL (1924)	4283	2006	2277	98	20	78	43	
FEFER A (1938)	2775	686	2089	97	23	74	28	
FELDMANN M (1944)	3750	2237	1513	92	42	50	40	
FELDMANN M (1937)	2698	476	2272	113	23	90	73	
FRANKLIN EC (1928)	2854	365	2489	136	36	100	20 A	
FREEDMAN SD (1928)	3148	58	3090	49	10	39	64 N	
FUDENBERG HH (1928)	9602	516	9086	371	26	345	25	
GERSHON RK (1932)	2746	1685	1061	91	38	53	30 A	
GEWURZ H (1936)	2930	879	2051	145	31	114	20	
GILDEN RV (1935)	4391	613	3778	157	21	136	27	
GOOD RA (1922)	17679	349	17330	672	27	645	76 A	
GRAHAM RC (1934)	3322	2852	470	49	20	29	67	
GREAVES MF (1941)	3657	1386	2271	80	24	56	45	
GREEN I (1926)	4329	635	3694	118	18	100	36	
HABER E (1932)	5650	1538	4117	165	24	141	34 B	
HELLSTROM I (1932)	6500	4279	2221	102	49	53	63	
HELLSTROM KE (1934)	6145	684	5461	103	21	82	59	
HENNEY CS (1941)	2732	1393	1339	86	39	47	31	
HEREMANS JF (1927)	3524	69	3455	113	5	108	31 C	
HERSH EM (1935)	4324	1802	2522	159	43	116	27	
HERZENBERG LA (1931)	3569	485	3084	78	11	67	45 A	
HOLBOROW EJ (1918)	3314	213	3101	101	17	84	32	
HONG R (1929)	2661	355	2306	102	18	84	25	
ISHIZAKA K (1925)	5102	2329	2773	170	45	125	30	
ISHIZAKA T (1926)	3508	1176	2332	93	38	55	37	
JOHANSSON SGO (1938)	3855	1308	2547	95	16	79	45	
JONDAI MB (1943)	3533	2270	2263	39	17	22	50	
KABAT CA (1914)	3020	523	2497	100	24	76	30 AB	
KATZ DH (1943)	3544	2123	1421	92	40	52	38	

	A	B	C	D	E	F	G	H
PERLMANN P (1919)	4373	1155	3218	127	24	103	34	
PHILLIPS RA (1937)	2487	436	2051	82	18	64	30	
PRESSMAN D (1916)	3184	28	3156	216	3	213	14	
QUE PG (1925)	3877	772	3105	130	18	112	29	
RAPP HJ (1923)	4367	240	4157	129	10	119	34	
REISELD RA (1926)	3680	791	2889	121	18	103	30	
ROITLIM (1927)	4014	575	3489	99	6	90	40	
ROSEN FS (1930)	4939	541	4398	147	20	127	33	
ROSENTHAL AS (1939)	3938	889	3049	80	20	60	49	
ROWE DS (1925)	2692	1407	1285	89	32	57	30	
SCHUR PH (1933)	3561	680	2381	111	22	89	32	
SCHWARTZ RS (1928)	2840	946	1894	67	19	49	42	
SEGMILLER JE (1920)	4753	704	4049	164	15	149	28 A	
SELA M (1924)	4785	537	4248	215	13	202	22 AB ^b	
SELL S (1935)	2719	1764	955	104	57	47	26	
SHEVACH EM (1943)	2456	1047	1409	64	15	49	38	
SIMMONS RL (1934)	4255	1454	2801	295	62	233	14	
SPRENT J (1941)	3045	890	2155	61	30	31	49	
STARZL TE (1926)	5119	2258	2861	188	66	122	27 B	
STEINBERG AD (1940)	2473	900	1673	140	36	104	18	
STORR RP (1935)	3563	1223	2340	160	54	106	22	
STROBER W (1937)	2821	362	2459	83	12	71	33	
SVEJGAARD A (1937)	2439	457	1982	102	21	81	23 R	
TALAN N (1934)	3550	795	2755	138	33	105	25	
TAN EM (1926)	2783	1047	1736	94	27	67	29	
TERASAKI PI (1929)	7379	734	6645	237	20	217	31	
TERRY WD (1933)	2817	609	2208	85	19	66	33	
TOMASI TB (1927)	3315	1313	2002	102	17	85	32	
UNR JW (1927)	3925	517	3408	110	10	100	35	
UHANUE ER (1934)	5100	2178	2922	119	44	75	42	
VANROOD JJ (1926)	2582	763	1819	119	37	82	21	
WAKSMAN BH (1919)	3405	293	3112	128	23	105	26 B	
WALDMANN TA (1930)	4094	1717	2377	115	29	86	35	

Immunology
(cont.)

	A	B	C	D	E	F	G	H
WARNER NL (1939)	3436	686	2750	100	28	72	34	
WARREN KS (1929)	2447	827	1620	178	60	118	13	E
WEIGLE WO (1927)	2723	513	2210	104	25	79	26	
WIGZELL HLR (1938)	7243	828	6415	136	16	120	53	
WILLIAMS RC (1928)	4037	882	3155	234	30	204	17	
WOLFF SM (1930)	2981	307	2674	149	13	136	20	
YUNIS EJ (1929)	3511	942	2569	189	35	154	18	
ZIFF M (1913)	2742	195	2547	159	10	149	17	

Virology

BALTIMORE D (1938) *	6773	2332	4441	131	21	110	51	AB
BISHOP JM (1936)	3545	423	3122	115	24	91	30	A
BLACK PH (1930)	2690	392	2298	97	14	83	27	
CHANOCK RM (1924)	6089	456	5633	200	8	192	30	A
CHOPPIN PW (1929)	3008	230	2778	64	7	57	47	A
DUESBERG PH (1936)	3071	1869	1202	50	21	29	61	
FRIEDMAN RM (1932)	2484	1115	1369	94	47	47	26	
HARTLEY JW (1928)	4208	1388	2820	38	8	30	110	
HENLE G (1912)	6816	2212	4604	103	13	90	66	A
HENLE W (1910)	6223	1423	4800	113	24	89	55	A
HILLEMANN MR (1919)	3447	530	2917	136	26	110	25	B
JOKLIK WK (1926)	3084	678	2406	64	11	53	48	A
KRUGMAN S (1911)	2911	1754	1157	63	36	27	46	AB
MELNICK JL (1914)	6427	440	5987	297	49	248	21	
MERIGAN TC (1934)	3544	677	2867	138	26	112	25	
NAHMIA AJ (1930)	3198	1752	1446	97	37	60	32	
PRINCE AM (1928)	3754	2350	1404	94	34	60	39	
PURCELL RH (1935)	4406	880	3526	126	17	109	34	
RAPP F (1929)	3903	840	3063	196	40	156	19	
RAWLS WE (1933)	3117	1226	1886	118	29	89	26	
ROIZMAN B (1929)	3290	300	2990	88	13	75	37	A
ROWE WP (1926)	6655	1562	5093	107	21	86	62	A

Physiology
(cont.)

	A	B	C	D	E	F	G	H
BUTCHER RW (1930)	6511	1935	4576	46	12	34	141	
CAHILL GF (1927)	3783	943	2840	90	26	64	42	
CARLSON LA (1928)	3374	1858	516	143	80	63	23	
COBURN JW (1932)	2928	574	2354	147	36	111	19	
COVELL JW (1936)	4579	477	4152	88	9	79	52	
DAVIS JO (1916)	2483	592	1891	108	18	90	22	AD
DIAMOND JM (1937)	2845	1643	1702	87	45	42	32	AB
DOWLING JE (1935)	2695	1536	1159	52	25	27	51	AB
GIBSON QH (1918)	2588	600	1988	110	24	86	23	ABC
GROSSMAN MI (1919)	6693	913	5780	247	51	196	27	B
HUBEL DH (1926) *	3764	2814	950	33	23	10	114	ABF
JOHNSON LR (1942)	2760	1690	1070	149	63	86	18	
JOUVET M (1925)	3137	1600	1537	97	20	77	32	U
KLEEMAN CR (1923)	2552	280	2272	111	13	98	22	
KRNJEVIC K (1927)	2821	2170	651	73	48	25	38	N
LASSEN NA (1926)	2995	912	2083	130	35	95	23	
LEVER AF (1929)	3397	15	3382	131	2	129	25	S
MACKLEM PT (1931)	3247	1018	2229	94	23	71	34	
MASSRY SG (1930)	2965	1059	1906	157	40	117	18	
MILIC-EMILI J (1931)	2439	428	2011	71	8	63	34	
ORLOFF J (1921)	2531	581	1950	60	9	51	42	E
PAGE IH (1901)	2715	222	2493	96	32	64	28	ABE1
PARK CR (1916)	3877	68	3809	63	2	61	61	A
PORTER JC (1925)	2730	243	2487	92	20	72	29	
RECTOR FC (1929)	3623	691	2932	75	9	66	48	
RUDOLPH AM (1924)	2580	1055	1525	117	25	92	22	
SALTIN B (1935)	2777	512	2765	104	19	85	26	
SCHULTZ SG (1931)	3029	1366	1663	72	24	48	42	
SELDIN DW (1920)	2924	254	2670	66	9	57	44	BCE
SWAN HJC (1922)	4196	571	3625	175	10	165	23	
WALTER R (1937)	2857	802	2055	180	61	119	15	
WEIBEL ER (1929)	2958	1386	1572	87	28	59	34	A
WIESEL TN (1924) *	3634	813	2821	32	6	26	113	AB

**Virology
(cont.)**

	A	B	C	D	E	F	G	H
SAMBROOK J	2442	704	1738	29	7	22	84	
SCOLNICK EM (1940)	3493	1083	2410	80	22	58	43	
SHATKIN AJ (1934)	3347	876	2471	79	13	66	42	A
STEPHENSON JR (1942)	2582	1375	1207	104	44	60	24	
STROMINGER JL (1925)	6312	524	5788	209	12	197	30	ABE
VINUELA E (1937)	3471	270	3201	37	5	32	93	B
VOGT PK (1932)	3728	979	2749	68	16	52	54	A

Microbiology

FINLAND M (1902)	3252	472	2780	121	36	85	26	AB
GIBBONS RJ (1932)	2447	1410	1037	62	24	38	39	
GORBACH SL (1934)	3460	1654	1806	127	38	89	27	
KIRBY WMM (1914)	2568	205	2363	45	11	34	57	
KOPROWSKI H (1916)	4229	444	3785	202	14	188	20	ABU
LUDERITZ O (1920)	2980	879	2101	81	11	70	36	
MCCARTHY BJ (1934)	3943	435	3508	85	12	73	46	
NATHANS D (1928)*	2781	468	2313	54	9	45	51	A
PHILIPSON L (1929)	2911	489	2422	90	12	78	32	
RAZIN S (1929)	2451	1119	1332	92	32	60	26	
REMINGTON JS (1931)	3354	822	2532	133	30	103	25	
ROBBINS JB (1932)	2436	864	1572	75	14	61	32	
SEVER JL (1932)	3444	704	2740	184	39	145	18	
STANIER RY (1916)	2506	1023	1483	42	7	35	59	ABC
TAKEUCHI T (1923)	4480	932	3548	430	103	327	10	
UMEZAWA H (1914)	7808	1767	6041	546	54	492	14	Bfdl
WEINSTEIN L (1909)	3031	526	2505	153	45	108	19	B

Physiology

AUSTEN WG (1930)	3792	476	3316	190	24	166	19	S
BROWN JJ (1927)	3368	1927	1441	144	65	84	22	S

Histology

	A	B	C	D	E	F	G	H
DAHLSTROM A (1941)	2513	1035	1478	59	29	30	42	
FALCK B (1927)	2721	454	2267	100	19	81	27	
FAWCETT DW (1917)	2472	1355	1117	55	19	36	44	A
JONSSON G (1941)	3290	911	2379	126	53	73	26	
LEBLOND CP (1910)	4024	57	3967	76	6	70	52	BCN
ORCILL (1937)	3600	1167	2433	193	55	138	18	
OWMAN C (1939)	3448	663	2785	160	23	137	21	

Hematology

BAEHNER RL (1934)	2645	1583	1062	102	34	68	25	
BERNARD J (1907)	2656	465	2191	273	81	192	9	UV
BEUTLER E (1928)	4483	2542	1941	249	122	127	18	AB
CLEGG JB (1936)	2992	1381	1611	88	22	66	34	
CLINE MJ (1934)	3699	1483	2216	130	46	84	28	
FINCH CA (1915)	2951	350	2601	106	15	91	27	AB
GIBLETT ER (1921)	2447	796	1651	79	17	62	30	A
HERBERT VD (1927)	4716	2069	2647	147	49	98	32	
HOFFBRAND AV (1935)	2896	824	2072	137	41	96	21	
HOLM G (1930)	3207	901	2306	82	29	53	39	
MCCULLOCH EA (1926)	3161	249	2912	81	10	71	39	N
METCALF D (1929)	5099	2085	3014	130	66	64	39	H
NATHAN DG (1929)	3269	625	2644	142	29	113	23	
NILSSON IM (1923)	2914	478	2436	193	42	151	15	
OSKI FA (1932)	2816	952	1864	165	42	123	17	
OWEN CA (1915)	2475	266	2209	190	33	157	13	
PACKHAM MA (1927)	3233	758	2475	100	22	78	32	
RATNOFF OD (1916)	2945	681	2264	127	40	87	23	A
SELIGMANN MG (1927)	4248	1230	3018	126	33	93	33	
SHULMAN NR (1925)	2890	774	2116	63	10	53	45	
WEATHERALL DJ (1933)	3232	756	2476	115	39	76	28	C
WEISS HJ (1929)	3260	2588	672	85	62	23	38	

Table 2: Academy memberships of the 238 authors in the life sciences, second group, including the number of authors from each academy.

A = National Academy of Sciences, US	52
B = American Academy of Arts and Sciences	37
C = Royal Society of London, UK	10
D = American Philosophical Society	2
E = Institute of Medicine, US	7
F = Deutsche Akademie der Naturforscher Leopoldina, DDR	5
H = Australian Academy of Science	4
I = Austrian Academy of Sciences	1
J = Royal Academy of Sciences, Letters and Fine Arts of Belgium	1
N = Royal Society of Canada	4
R = Royal Danish Academy of Sciences and Letters	1
S = Royal Society of Edinburgh, UK	2
T = Academy of Finland	1
U = Academy of Sciences of France	4
V = Académie Française	1
Z = Indian National Science Academy, New Delhi	1
a = Royal Irish Academy	1
b = Israel Academy of Sciences and Humanities	1
d = Japan Academy	1
f = Royal Netherlands Academy of Sciences and Letters	1
i = Pontifical Academy of Sciences	1
l = Royal Swedish Academy of Sciences	6
u = Yugoslav Academy of Sciences and Arts	1

number of cited papers published, as a first or secondary author. Also listed is the author's "citation rate"—the average number of citations per paper. Citation rates are calculated by dividing citations received (column A) by the number of cited papers (column D). Each author's year of birth is shown in parentheses.

Taken as a group, the authors in these six life sciences disciplines received more

Table 3: Authors, listed in this essay, who are members of four academies.

Klein G	ABDI
Kunkel H G	ABEI
Lederer E	FITa
Nossal G J V	ABHZ
Page I H	ABEI
Sela M	ABbi
Umezawa H	BFdl

Table 4: Newly elected members of the US National Academy of Sciences who are on the list of 1,000 most-cited contemporary authors.

Conney A H	Pharmacology
Costa E	Neuropharmacology
Cuatrecasas P	Biochemistry
Davis J O	Physiology
Eastman D E	Physics
Gibson Q H	Physiology
Herzenberg L A	Immunology
Kochi J K	Organometallic Chemistry
McLafferty F W	Analytical Chemistry
Miller J F A P	Immunology
Pastan I H	Biochemistry
Paul W E	Immunology
Shreffler D C	Genetics
Steinberg D	Biochemistry
Sugimura T	Oncology
Thomas E D	Oncology
Weissbach H	Molecular Biology

citations as secondary authors than as primary authors. This was also the case for the physical, chemical, and life sciences disciplines already covered in previous essays.^{2,3} Furthermore, the authors in this study also published more cited papers as secondary authors.

Nobel laureates are indicated by asterisks in Table 1. Seven of the 238 authors in this study have won Nobel prizes—three immunologists, two physiologists, one microbiologist, and one virologist.

Academy memberships are denoted by the letters in column H of Table 1. A key to these letter codes appears in Table 2. Only 86 of the 238 authors in this group hold memberships in national academies. Of these, the majority (50)

Table 5: Discipline averages for authors listed in this essay. A = number of authors on list. B = average number of citations received. C = average primary citations. D = average secondary citations. E = average number of cited papers. F = average papers as first author. G = average papers as secondary author. H = number of authors with academy memberships. I = number of Nobelists. J = average birth year.

Discipline	A	B	C	D	E	F	G	H	I	J
Hematology	22	3283	1083	2200	132	40	92	8	0	1926
Histology	7	3153	806	2347	110	29	81	2	0	1930
Immunology	128	4132	1126	3006	129	27	102	37	3	1930
Microbiology	17	3416	836	2580	148	29	119	7	1	1923
Physiology	35	3319	971	2348	105	27	78	17	2	1927
Virology	29	4069	1056	3013	108	22	86	15	1	1929

are members of one academy, 20 are members of two, and nine of three academies. Table 3 lists those seven scientists who are members of *four* academies. Taken as a group, the average age of academy members was 58 years, and 51 for nonmembers.

The US National Academy of Sciences (NAS) recently announced the election of 60 new members, 17 of whom appear on our list of 1,000 authors. They are shown in Table 4, including the disciplines to which they were assigned in this study.

Table 5 presents citation and authorship data averaged over the entire group of scientists within each discipline. The microbiologists have the highest average of cited papers per author (148), but they are the second smallest group of authors (17). They also are the oldest, with an average age of 59 years. Immunology is the largest group with 128 authors. It has the highest average of citations per author (4,132). Only the virologists also averaged more than 4,000 citations.

C.P. Leblond, McGill University, Montreal, Canada, was surprised to see only seven authors listed under his discipline of histology. He asserts, "More than any other group, histologists are responsible for the vast amount of new knowledge on fine structure provided by the electron microscope. It seems that the knowledge of cell organelles and tissue detail is one of the most important developments of modern science. Consciously or unconsciously, physiologists and biochemists

have to refer to fine structure if they are to understand intracellular happenings."⁵

Leblond offers an explanation for the presumably small number of histologists identified in this study. He suggests that the findings of histologists are "taken for granted" soon after publication. Consequently, they quite often are not explicitly cited in later publications.⁵ This is a variation on the notion of "citation obliteration," a phenomenon I have discussed *ad infinitum*. However, it would be time consuming, though not impossible, to collect evidence to support the notion that this happens more often in histology than in other fields.

It may be that the average histology paper contains fewer references than, say, the average immunology paper. This has been the case for other fields that are not well represented in this list—plant sciences, for example.³ But a check of the *Journal Citation Reports*[®] (*JCR*[®]) volume of *SCI* shows that the average number of references per paper in the leading histology journals is not significantly different from journals in immunology.

I suspect that the problem is in field definition—histology is not a well-defined field. It is rather interesting that histochemistry has produced specialty journals, but none on histology *per se*. To make sure this was not peculiar to *SCI* or *Current Contents*[®] (*CC*[®]) coverage, we checked *Ulrich's International Periodicals Directory*.⁶ It lists more than 65 journals under "cytology and

histology," but only one has the word "histology" in its title—*Archivum Histicologicum Japonicum*. I therefore presume that the kind of research Leblond has in mind is reported in journals of cell biology or histochemistry. If so, why don't the histologists in our study view themselves as cell biologists? In the third part of this study, we identified 56 cell biologists.³ It is interesting that the NAS has a section for cell biology but not for histology. Perhaps it would have been appropriate to assign our group of histologists to that category.

When we calculate average citations per author in Table 5, you should keep in mind that we are dealing with multiauthored works. In this study, we have credited each author of a multiauthored paper with the *full* citation count. Derek J. de Solla Price, Yale University, proposed giving *proportional* credit to each author instead of equal credit.⁷ Thus, if a paper was written by two authors, each would get half the citations it received; three authors would get one-third each, and so on.

When we recalculated citations to multiauthored papers using Price's method, we found that 47 scientists listed here would not have made the list of 1,000 most-cited contemporary scientists: 19 from immunology, ten from physiology, seven from hematology, six from microbiology, three from virology, and two from histology.

Of course, we couldn't accurately determine who did the most important work on a multiauthored paper unless we could ask each research team "to tell the truth"—would the "real" author please stand up! T.C. Hsu, Texas Medical Center, Houston, suggested the possibility of assigning citations the way golf tournaments award prize money.⁸ That is, the first author would get full credit for all citations, the second would get half that number, the third would receive half again, and so on. But credit would be limited to the first four authors. Hsu

clearly never expects to be a member of a team of high-energy physicists!

Fred Rapp, Hershey Medical Center, Pennsylvania State University, believes the golf tournament method would not work.⁹ He claims that in his own field of virology, the convention for ordering names is as follows: students and postdoctorates first, the senior member of the research group last, and everyone else—technicians, support staff, and drug and tissue suppliers—are placed in between. As you would expect, Rapp follows this convention. We identified 147 of his papers as having more than one coauthor. Of these, he appears last on 107, first on 27, and in between on only 13. Also, 90 of Rapp's papers were coauthored with one other person, and he is last on 71 of these. These are all in addition to ten other papers he wrote alone.

Rapp goes on to say, "It may vary from field to field, but in immunology, virology, microbiology, or the others under review in this essay, I would suspect [this ordering sequence] to be the case. You can pick up any journal you wish, look at the names of the people in Table 1 in this essay, and you'll find that most will be last on the papers. If the key person isn't first, he or she is going to be last, but not in between."⁹

Although there are no statistical data on the frequency of this practice, it's true that a large number of "senior" authors put their names last on many papers—but not necessarily their best. Rapp notes that his name does come first on review papers.⁹ In fact, this is one of the reasons we were able to use first-author data for so long to identify most eminent scientists—they almost invariably write reviews or other "summary" papers on which they choose to be the first or only author. But there were important exceptions.

Until international standards for authorship are established and accepted by most leading journals, these proposals

will remain futile and citation data will always have to be subjected to further review by peer groups. Citation data will remain, as before, *indicators* and not precise measurements of whatever one is trying to examine—eminence, importance, impact, and so on.

The next part of this essay will present citation and authorship data on 281 authors in the following life sciences disciplines: cardiology, endocrinology, gas-

troenterology, nephrology, neurobiology, neurology, neuropharmacology, nuclear medicine, oncology, pathology, pharmacology, psychiatry, and surgery.

* * * * *

My thanks to Bella Teperov and Alfred Welljams-Dorof for their help in the preparation of this essay.

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REFERENCES

1. **Garfield E.** The 1,000 contemporary scientists most-cited 1965-1978. Part 1. The basic list and introduction. *Current Contents* (41):5-14, 12 October 1981.
2. The 1,000 most-cited contemporary authors. Part 2A. Details on authors in the physical and chemical sciences and some comments about Nobels and academy memberships. *Current Contents* (9):5-13, 1 March 1982.
3. The 1,000 most-cited contemporary authors. Part 2B. Details on authors in biochemistry, biophysics, cell biology, enzymology, genetics, molecular biology, and plant sciences. *Current Contents* (21):5-13, 24 May 1982.
4. Are the 1979 prizewinners of *Nobel class*? *Essays of an information scientist*. Philadelphia: ISI Press, 1981. Vol. 4. p. 609-17.
5. **Leblond C P.** Personal communication. 13 April 1982.
6. *Ulrich's international periodicals directory*. New York: Bowker, 1981. p. 185-7.
7. **Price D J D.** Letter to editor. (Multiple authorship.) *Science* 212:986, 1981.
8. **Hsu T C.** Personal communication. 22 March 1982.
9. **Rapp F.** Telephone communication. 7 April 1982.