Current Comments

The 1,000 Most-Cited Contemporary Authors. Part 2D. Details on Authors in Cardiology, Endocrinology, Gastroenterology, Nephrology, Neurobiology, Neurology, Neuropharmacology, Nuclear Medicine, Oncology, Pathology, Pharmacology, Psychiatry, and Surgery

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This essay is the fifth in our series on the 1,000 most-cited contemporary scientists. We call these authors "contemporary" because the study is based on data for articles they published from 1965 to 1978. We limited the study to articles published in journals indexed in *Science Citation Index*® (*SCI*®). We excluded citations to books by these authors but did include citations to all papers by them, regardless of the position of their name in an article's by-line.

The first part of this series presented the entire list of authors.[1] In Part 2A, citation and authorship data were provided 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] That was followed by Part 2B, which presented details on 267 authors in seven life sciences fields: biochemistry, molecular biology, biophysics, cell biology, enzymology, genetics, and plant sciences.[3] Part 2C covered 238 authors in six additional life sciences: immunology, virology, microbiology, physiology, histology, and hematology.[4] This essay covers 281 scientists in 13 additional fields. The next part of this series concludes the study with an analysis of the institutional affiliations of all 1,000 authors for the 38 different fields represented in the overall study.

Assigning the 1,000 individual authors to these specialties turned out to be a challenging task. To avoid mistaken classifications, we let the authors themselves tell us under what disciplines they wanted to be placed. We sent each of them a questionnaire that included a "menu" of disciplines—the authors simply checked off their preferences. But some of them checked as many as five disciplines. When this happened, we relied on various indicators to assign the author to a single specialty—such as articles, institutional affiliations, academy memberships, and the like.

I've indicated elsewhere how much effort was expended to avoid the problem of homographs. In most cases, I think we've managed to avoid mistaken identities for different authors with the same surname and initials. Unfortunately, we recently learned that one of the original 1,000 names[1] turned out to be a homograph. Usually, homographs can be differentiated by simply looking at the journals in which they publish. But in this case, two people with the same name both published in (and were cited by) biochemistry journals. Had the surname been a common one, like Jones or Smith, we would have routinely checked institutional affiliations in addition to journal data. But since the name was not a common surname, we did not suspect that it might be a homograph. After we discovered that the entry for this name represented the work of two people, we

Table 1: The most-cited scientists in the clinical sciences, 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. An asterisk indicates Nobel prizewinners.

Oncology	A	B	C	D	E	F	G	H
AARONSON SA (1942)	6072	2507	3565	140	36	104	43	
AMES BN (1928)	4937	2010	2927	75	17	58	65	AB
BALDWIN RW (1927)	2866	2330	536	122	75	47	23	
BLUMBERG BS (1925)*	5840	2637	3203	157	44	113	37	A
BODEY GP (1934)	4580	2076	2504	217	79	138	21	
CANELLOS GP (1934)	2453	600	1853	109	30	79	22	
CARBONE PP (1931)	4962	859	4103	141	19	122	35	
CLIFFORD P (1921)	3444	176	3268	66	14	52	52	
DEVITA VT (1935)	5163	1436	3727	181	38	143	28	
DOLL R (1912)	2939	880	2059	112	46	66	26	BCg
DRUCKREY H (1904)	2597	2136	461	41	34	7	63	
DULBECCO R (1914)	2921	980	1941	50	19	31	58	ABCc
FISHER B (1918)	2763	2044	719	138	86	52	20	
FISHMAN WH (1914)	2620	1201	1419	111	33	78	23	
FREI E (1924)	3909	723	3186	165	37	128	23	
FREIREICH EJ (1927)	4735	221	4514	190	11	179	24	
GOLD P (1936)	3958	2189	1769	65	17	48	60	N
GROVER PL (1933)	3158	1236	1922	61	19	42	51	
HEIDELBERGER C (1920)	4214	568	3646	134	13	121	31	A
HELLMAN L (1921)	3112	411	2701	163	15	148	19	
HENDERSON ES (1932)	2609	503	2106	94	9	85	27	
HERBERMAN RB (1940)	5027	1137	3890	207	39	168	24	
HOLLAND JF (1925)	3743	618	3125	210	32	178	17	
HUEBNER RJ (1914)	7536	1473	6063	215	10	205	35	A
IVANKOVIC S (1931)	2485	443	2042	48	15	33	51	
KAPLAN HS (1918)	5825	1282	4543	201	45	156	28	AB
LONDON WT (1932)	2878	554	2324	119	18	101	24	
MILLER EC (1920)	3044	607	2437	97	19	78	31	A
MILLER JA (1915)	5007	1571	3436	246	69	177	20	A

Cardiology (cont.)	A	B	C	D	E	F	G	H
JAMES TN (1925)	2539	1865	674	138	74	64	18	
KAKKAR VV (1937)	2554	1419	1135	107	41	66	23	
KANNEL WB (1923)	2518	1618	900	99	46	53	25	
LARAGH JH (1924)	5681	1001	4680	149	34	115	38	
LAU SH (1926)	2943	179	2764	104	7	97	28	
LEES RS (1934)	6410	383	6027	70	15	55	91	
LEVY RI (1937)	10784	1003	9781	166	32	134	64	
LOWN B (1921)	3434	1875	1559	145	41	104	23	
MAROKO PR (1936)	3102	1833	1269	92	24	68	33	
MASON DT (1932)	5700	1577	4123	457	53	404	12	
MORROW AG (1922)	4160	360	3800	186	19	167	22	
PARMLEY WW (1936)	3512	1009	2503	126	29	97	27	
PITT B (1932)	2626	385	2241	136	23	113	19	
ROBERTS WC (1932)	3342	1470	1872	237	80	157	14	
ROBERTSON JI (1928)	3310	2	3308	128	1	127	25	S
ROSEN KM (1937)	2838	890	1948	162	33	129	17	
ROSS J (1928)	7756	1181	6575	153	27	126	50	
SCHERLAG BJ (1932)	2571	1179	1392	92	27	65	27	
SMITH TW (1936)	4037	1798	2239	141	45	96	28	
SOBEL BE (1937)	4534	669	3865	163	25	138	27	
SONNENBLICK EH (1932)	8301	1763	6538	240	31	209	34	

Gastroenterology								
ARIAS IM (1926)	3175	616	2559	112	17	95	28	
DIETSCHY JM (1932)	2504	1556	948	69	26	43	36	

Oncology (cont.)	A	B	C	D	E	F	G	H
MOORE GE (1920)	4009	1618	2391	227	85	142	17	
MORRIS HP (1900)	4759	26	4733	305	2	303	15	
MORTON DL (1934)	4214	1911	2303	131	29	102	32	
OLD LJ (1933)	7892	1271	6621	141	14	127	55	ABE
PITOT HC (1930)	2678	423	2255	158	22	136	16	
POTTER M (1924)	3042	927	2115	108	23	85	28	A
PREUSSMAN R (1928)	2692	296	2396	67	16	51	40	
ROSENBERG SA (1927)	2448	979	1469	63	22	41	38	
RUOSLAHTI E (1940)	2885	1218	1667	90	31	59	32	
SACHS L (1924)	7561	48	7513	173	8	165	43	D
SJOGREN HO (1935)	3467	1213	2254	58	18	40	59	
SUGIMURA T (1926)	2837	785	2052	198	39	159	14	A
SUTNICK AI (1928)	2798	713	2085	85	42	43	32	
TEMIN HM (1934) *	3570	2076	1494	67	29	38	53	ABD
THOMAS ED (1920)	4702	1095	3607	203	32	171	23	A
TODARO GJ (1937)	8933	2237	6696	151	37	114	59	
WALLACH DFH (1926)	5623	1007	4616	126	31	95	44	
YOUNG RC (1940)	2503	907	1596	152	24	128	16	
ZBAR B (1938)	3131	1275	1856	67	19	48	46	
Cardiology								
BRAUNWALD E (1929)	13483	1391	12092	342	55	287	39	ABE
BRUNNER HR (1937)	2632	1041	1591	53	18	35	49	
BURCH GE (1910)	2765	1489	1276	230	151	79	12	
COOLEY DA (1920)	2889	710	2179	207	37	170	13	
DAMATO AN (1930)	4551	816	3735	185	20	165	24	
DUSTAN HP (1920)	2499	264	2235	76	11	65	32	E
EPSTEIN SE (1935)	6243	1528	4715	259	37	222	24	
FEIGENBAUM H (1933)	3123	928	2195	116	27	89	26	
GORLIN R (1926)	5894	464	5430	208	14	194	28	
HARRISON DC (1934)	4196	360	3836	296	28	268	14	
HELFANT RH (1937)	2484	841	1643	106	30	76	23	D
HOFFMAN BF (1925)	3096	308	2788	156	15	141	19	

Gastroenterology (cont.)	A	B	C	D	E	F	G	H
HOFMANN AF (1931)	4963	1243	3720	196	30	166	25	
ISSELBACHER KJ (1925)	4771	432	4339	193	16	177	24	ABE
LIEBER CS (1931)	5300	2002	3298	185	53	132	28	
MCGUIGAN JE (1931)	2558	1510	1048	118	49	69	21	
SHERLOCK S (1918)	5670	1008	4662	274	48	226	20	
SUMMERSKILL WH (1926)	2631	272	2359	136	14	122	19	
WALSH JH (1938)	2997	888	2109	123	27	96	24	
WILLIAMS R (1933)	5234	398	4836	262	31	231	19	
Nephrology								
MICHAEL AF (1928)	3012	643	2369	120	9	111	25	
Nuclear Medicine								
WAGNER HN (1927)	4454	403	4051	304	33	271	14	
Pathology								
BENSCH KG (1928)	2507	908	1599	77	10	67	32	
COHEN AS (1926)	2749	951	1798	136	19	117	20	
ERICSSON JL (1932)	3055	861	2194	108	33	75	28	
FARBER E (1918)	2875	511	2364	113	22	91	25	
FISHER ER (1923)	2854	1243	1611	174	89	85	16	
GREY HM (1932)	4545	1368	3177	77	23	54	59	
HOBBS JR (1929)	2708	1106	1602	124	41	83	21	
LACY PE (1924)	2703	1354	1349	74	14	60	36	
LANDON J (1931)	2712	604	2108	79	15	64	34	

	A	B	C	D	E	F	G	H
Pathology (cont.)								
MARCHESI VT (1935)	3395	1274	2121	51	13	38	66	
MUSTARD JF (1927)	5442	1428	4014	202	37	165	26	N
NOVIKOFF AB (1913)	2753	1293	1460	61	28	33	45	A
POLAK JM (1939)	3158	1219	1939	117	46	71	26	
POPPER H (1903)	3367	756	2611	131	46	85	25	ABI
PORTER KA (1925)	2761	446	2315	80	7	73	34	
POSTE G (1944)	2565	1403	1162	80	47	33	32	
RUBIN E (1928)	2761	1669	1092	126	54	72	21	
SCHAFFNER F (1920)	2525	642	1883	106	35	71	23	
SPICER SS (1914)	3131	712	2419	148	23	125	21	
TRUMP BF (1932)	3581	1047	2534	178	35	143	20	
TURK JL (1930)	3243	1234	2009	128	39	89	25	
WARD PA (1934)	4044	3039	1005	132	68	64	30	
WHITE JG (1929)	4002	1892	2110	219	95	124	18	
Psychiatry								
BUNNEY WE (1930)	2743	1030	1713	89	24	65	30	
DAVIS JM (1933)	3462	547	2915	165	45	120	20	
GOODWIN FK (1936)	2793	521	2272	106	19	87	26	
MURPHY DL (1936)	2624	934	1690	130	34	96	20	
SCHILDKRAUT JJ (1934)	3026	2117	909	59	37	22	51	
Endocrinology								
ARIMURA A (1923)	8569	1534	7035	248	42	206	34	
ARNAUD CD (1929)	2554	911	1643	86	17	69	29	
AURBACH GD (1927)	5245	441	4804	120	14	106	43	
AVIOLI LV (1931)	2454	1168	1286	119	36	83	20	
BARTTER FC (1914)	2816	433	2383	154	14	140	18	A
BAULIEU EE (1926)	3573	832	2741	150	25	125	23	
BERSON SA (1918)	3946	1621	2325	39	16	23	101	AC
BESSER GM (1936)	3567	857	2710	116	34	82	30	
BIERMAN EL (1930)	2606	526	2080	92	21	71	28	
BIRNBAUMER L (1939)	3198	1092	2106	38	10	28	84	

	A	B	C	D	E	F	G	H
Endocrinology (cont.)								
MIGEON CJ (1923)	3274	161	3113	134	9	125	24	
MURPHY BEP (1929)	2565	2363	202	40	25	15	64	
NISWENDER GD (1940)	3749	1690	2059	93	19	74	40	
ODELL WD (1929)	4523	1745	2778	119	27	92	38	
O'MALLEY BW (1936)	6044	1653	4391	164	36	128	36	
PEARSE AGE (1916)	6151	2628	3523	186	36	150	33	
PORTE D (1931)	4584	2009	2575	120	25	95	38	
POTTS JT (1932)	5402	461	4941	172	10	162	31	
RAISZ LG (1925)	2569	903	1666	95	33	62	27	
REDDING TW (1933)	2497	564	1933	77	24	53	32	
REICHERT LE (1932)	2913	664	2249	79	31	48	36	
RENOLD AE (1923)	2997	136	2861	122	11	111	24	
RIVIER J (1941)	2443	270	2173	76	20	56	32	
RODBELL M (1925)	4652	1904	2748	55	20	35	84	
ROSS GT (1920)	4868	231	4637	129	15	114	37	
ROTH J (1934)	6987	991	5996	221	59	162	31	
RYAN KJ (1926)	2478	483	1995	120	22	98	20	BE
SAWYER CH (1915)	3341	168	3173	149	4	145	22	AB
SCHALCH DS (1929)	2629	825	1804	82	15	67	32	
SCHALLY AV (1926) *	15340	2691	12649	489	70	419	31	AB
SOELDNER JS (1932)	2750	493	2257	119	13	106	23	
SPELLACY WN (1934)	2679	1833	846	143	107	36	18	
STEINER DF (1930)	3421	1252	2169	92	17	75	37	AB
TASHJIAN AH (1932)	3911	1723	2188	147	36	111	26	
TURKINGTON RW (1936)	2716	2049	667	84	60	24	32	
UNGER RH (1924)	6030	2064	3966	158	38	120	38	
UTIGER RD (1931)	3304	330	2974	79	9	70	41	
VALE W (1941)	4123	888	3235	99	17	82	41	
WIDE LE (1934)	2857	1138	1719	107	15	92	26	
WILLIAMS RH (1909)	3289	265	3024	127	14	113	25	
WILSON JD (1932)	3398	757	2641	95	18	77	35	
WOLFF J (1925)	2564	989	1575	92	32	60	27	
YALOW RS (1921)	4500	1704	2796	71	21	50	63	AB
YEN SSC (1927)	4108	1914	2194	124	35	89	33	

Endocrinology (cont.)

	A	B	C	D	E	F	G	H
BLOOM SR (1942)	3725	1313	2412	200	64	136	18	
BOWERS CY (1924)	3681	1027	2654	124	19	105	29	
BURGUS RC (1934)	2962	975	1987	47	12	35	63	
CATT KJ (1932)	3762	1098	2664	134	34	100	28	
CHOPRA IJ (1939)	2532	2051	481	96	49	47	26	
CONN JW (1907)	2944	918	2026	85	18	67	34	AEG
COY DH (1944)	2860	490	2370	137	29	108	20	
DAUGHADAY WH (1918)	3973	484	3489	96	17	79	41	
DICZFALUSY E (1920)	2758	278	2480	153	9	144	18	
EXTON JH (1933)	3143	1806	1337	63	23	40	49	
FELIG P (1936)	3961	2071	1890	151	54	97	26	
FISHER DA (1928)	2476	851	1625	162	53	109	15	
FORSHAM PH (1915)	3449		3449	135		135	25	
FRANTZ AG (1930)	2435	443	1992	58	7	51	42	
FRIESEN HG (1934)	2845	146	2699	109	6	103	26	BN
GORDEN P (1934)	2503	586	1917	86	26	60	29	
GORSKI J (1931)	3225	463	2762	83	17	66	38	
GRODSKY GM (1927)	2761	806	1955	84	17	67	32	
GRUMBACH MM (1925)	2867	229	2638	81	3	78	35	
GUILLEMIN R (1924) *	5884	632	5252	118	23	95	49	AB
HALL R (1931)	3132	667	2465	170	29	141	18	
INGBAR SH (1925)	2977	271	2706	125	6	119	23	
KAPLAN SL (1927)	2699	551	2148	84	18	66	32	
KASTIN AJ (1934)	6460	1917	4543	220	60	160	29	
KNOBIL E (1926)	2887	104	2783	73	5	68	39	
LIDDLE GW (1921)	4743	368	4375	100	11	89	47	A
LIPSETT MB (1921)	3512	325	3187	93	23	70	37	
LUFT R (1914)	2472	421	2051	107	17	90	23	ALI
MALAISSE WJ (1936)	2957	1609	1348	141	64	77	20	
MALAISSE-LAGAE F (1936)	2606	285	2321	88	7	81	29	
MCCANN SM (1925)	5528	466	5062	179	10	169	30	
MEITES J (1913)	5231	515	4716	180	11	169	29	
MIDGLEY AR (1933)	5874	1568	4306	94	15	79	62	

Pharmacology

	A	B	C	D	E	F	G	H
ANDEN NE (1937)	5929	5412	517	92	80	12	64	
AXELROD J (1912) *	12425	1418	11007	242	31	211	51	ABCE
BECKETT AH (1920)	2741	2184	557	203	147	56	13	
BOSMANN HB (1942)	3196	2532	664	164	97	67	19	
BREESE GR (1936)	2973	996	1977	73	25	48	40	
BRODIE BB (1909)	5668	1265	4403	110	30	80	51	AEP
BURNSTOCK G (1929)	3099	1213	1886	127	30	97	24	H
BUSCH H (1923)	4921	199	4722	273	30	243	18	
CONNEY AH (1930)	7968	3127	4841	180	26	154	44	A
CORRODI H (1929)	5010	2540	2470	55	29	26	91	
CURTIS DR (1927)	3819	3104	715	75	53	22	50	CH
DALY JW (1933)	6930	1107	5823	174	34	140	39	
DOLLERY CT (1931)	3016	792	2224	186	50	136	16	
FOUTS JR (1929)	2504	552	1952	109	11	98	22	
GARATTINI S (1928)	2833	163	2670	205	12	193	13	
GILLETTE JR (1928)	4907	818	4089	143	27	116	34	
GILMAN AG (1941)	3987	3039	948	41	12	29	97	
GOLDBERG ND (1931)	2461	605	1856	67	12	55	36	
GOLDSTEIN A (1919)	2524	1148	1376	111	45	66	22	A
HAKANSON R (1937)	2563	1132	1431	156	69	87	16	
HARDMAN JG (1933)	2973	723	2250	55	9	46	54	
IVERSEN LL (1937)	8391	3237	5154	141	58	83	59	C
JOHNSTON GA (1939)	3555	630	2925	89	33	56	39	
KAMETANI T (1917)	3741	3657	84	519	499	20	7	
KAPPAS A (1926)	2613	422	2191	145	25	120	18	
KATO R (1930)	2506	2323	183	113	82	31	22	
KOCH-WESER J (1927)	3764	1985	1779	138	53	85	27	
KOPIN IJ (1929)	6646	797	5849	230	17	213	28	
KRISHNA G (1934)	3050	1593	1457	105	24	81	29	
KUNTZMAN R (1933)	3691	812	2879	101	19	82	36	
KUO JF (1933)	3846	2482	1364	67	43	24	57	
LEFKOWITZ RJ (1943)	2991	1550	1441	99	41	58	30	
LEVIN W (1940)	4690	1015	3675	156	35	121	30	

	A	B	C	D	E	F	G	H
Pharmacology (cont.)								
LEVY G (1928)	4266	1900	2366	252	112	140	16	E
LU AYH (1937)	3578	1619	1959	90	28	62	39	
MARTIN GR (1933)	2551	345	2206	90	21	69	28	
MONCADA S (1944)	2507	875	1632	64	17	47	39	
NEFF NH (1935)	2590	741	1849	71	13	58	36	
ORRENIUS S (1937)	2481	1140	1341	87	16	71	28	
PRESSMAN BC (1926)	2595	1236	1359	55	14	41	47	
REMMER H (1919)	3013	1195	1818	73	23	50	41	
ROBISON GA (1934)	4994	2035	2959	51	11	40	97	
ROTH RH (1939)	3276	737	2539	141	32	109	23	
RUSSELL DH (1935)	2458	1572	886	120	55	65	20	
SANDLER M (1926)	2664	789	1875	118	38	80	22	
SCHWARTZ A (1929)	4526	1091	3435	284	65	219	15	
SJOERDSMA A (1924)	4758	347	4411	94	7	87	50	
SJOQVIST F (1933)	2667	264	2403	81	11	70	32	
SNYDER SH (1938)	13149	3030	10119	277	62	215	47	AB
SPECTOR S (1923)	3702	1405	2297	120	20	100	30	
SUTHERLAND EW (1915) *	10297	1924	8373	77	9	68	133	A
UNGERSTEDT U (1942)	4992	1282	3710	75	15	60	66	
VANE JR (1927)	9971	2147	7824	173	17	156	57	CI
VESELL ES (1933)	2556	1608	948	109	50	59	23	
WEISBURGER JH (1921)	2457	602	1855	154	30	124	15	
WEISS B (1937)	2888	930	1958	62	37	25	46	
WILLIAMS RT (1909)	2790	425	2365	177	41	136	15	C
Neuropharmacology								
AGHAJANIAN GK (1932)	4344	1504	2840	104	28	76	41	
BLOOM FE (1936)	4938	1695	3243	134	36	98	36	AB
CARLSSON A (1923)	4118	2878	1240	116	66	50	35	I
COSTA E (1924)	6430	726	5704	226	24	202	28	A
GLOWINSKI J (1936)	6362	2156	4206	156	13	143	40	J
Neuropharmacology (cont.)								
HOKFELT T (1940)	8268	3212	5056	171	68	103	48	
KUHAR MJ (1944)	2550	1110	1440	72	22	50	35	
PALKOVITS M (1933)	2783	1147	1636	121	40	81	23	
PLETSCHER A (1917)	3674	620	3054	126	21	105	29	
WURTMAN RJ (1936)	6330	2132	4198	226	56	170	28	
Neurobiology								
JONES EG (1939)	2523	1645	878	77	49	28	32	
OLSON LO (1942)	2597	931	1666	71	26	45	36	
Neurology								
ALTMAN J (1925)	2592	1980	612	122	67	55	21	
BRADY RO (1923)	5086	2017	3069	144	45	99	35	AG
CHANGEUX JP (1936)	6701	1555	5146	124	22	102	54	F
COGGESHALL RE (1932)	3766	615	3151	50	29	21	75	
COWAN WM (1931)	3100	831	2269	66	10	56	46	AE
ENGEL WK (1930)	4031	1120	2911	194	41	153	20	
FIELD EJ (1915)	2670	1328	1342	165	94	71	16	
GOLDSTEIN M (1924)	2577	1054	1523	96	65	31	26	
POWELL TPS (1923)	3646	254	3392	80	6	74	45	C
SEEMAN P (1934)	3276	2256	1020	76	40	36	43	
SIESJO BK (1930)	2883	501	2382	152	21	131	18	
SUZUKI K (1932)	2842	1412	1430	130	25	105	21	
THOENEN H (1928)	4506	1578	2928	142	41	101	31	F
Surgery								
DUDRICK SJ (1935)	2535	1085	1450	87	20	67	29	

learned that, although both were highly cited, neither alone was cited enough to meet the threshold for inclusion in the top 1,000. While it is a somewhat belated gesture to seek out the occupant of the 1,000th chair, we did so. Thus, we've added A.G. Frantz to the list of endocrinologists. Our apologies to him, and to J. Gergely, Boston Biomedical Research Institute, and J. Gergely, L. Eotros University, Budapest, Hungary.

Table 1 lists the names of the 281 authors classified under cardiology, endocrinology, gastroenterology, nephrology, neurobiology, neurology, neuropharmacology, nuclear medicine, oncology, pathology, pharmacology, psychiatry, and surgery. We originally had a separate category for neuroendocrinology, which included one author. However, we recently learned that several authors listed as endocrinologists could just as easily have been classified as neuroendocrinologists. Unfortunately, we could not contact those individuals to confirm their reassignment before we went to press. Instead, we abolished the category to avoid giving the unfair impression that only one neuroendocrinologist appears on our list. The single author who formerly appeared in that category was transferred to endocrinology.

In order to discourage invidious comparisons between individual citation counts, the authors are arranged in alphabetical order under the appropriate specialty heading. Even 1,000 authors are a small sample of the estimated 500,000 regularly publishing scientists worldwide. If we were able to extend the list to include 2,000 authors, almost all would still be *of Nobel class.*[5] Indeed, 5,000 names would be a more appropriate number to cover science worldwide.

Table 1 includes information on each author's total citations and the total number of *cited* papers. These figures are broken down to show how many citations were received as a primary or secondary author, and how many papers were published as a first or second author. Also, the author's citation rate is listed—that is, the average number of citations per paper. Citation rate is calculated by dividing total citations received (column A) by the total number of cited papers (column D). The author's year of birth is shown in parentheses after the name.

Table 2: Academy memberships of the 281 authors in the life sciences, third group, including the number of authors from each academy.

A	=	National Academy of Sciences, US	37
B	=	American Academy of Arts and Sciences	19
C	=	Royal Society of London, UK	9
D	=	American Philosophical Society	2
E	=	Institute of Medicine, US	10
F	=	Deutsche Akademie der Naturforscher Leopoldina, DDR	4
G	=	National Academy of Sciences of Argentina	2
H	=	Australian Academy of Science	2
J	=	Royal Academy of Sciences, Letters and Fine Arts of Belgium	1
L	=	Bulgarian Academy of Science	1
N	=	Royal Society of Canada	3
P	=	Czechoslovakian Academy of Sciences	1
S	=	Royal Society of Edinburgh, UK	1
b	=	Israel Academy of Sciences and Humanities	1
c	=	Lincei National Academy, Italy	1
f	=	Royal Netherlands Academy of Sciences and Letters	1
g	=	Norwegian Academy of Science and Letters	1
l	=	Royal Swedish Academy of Sciences	2

Taken as a group, the authors in 12 of the 13 life sciences in this study received more citations as secondary authors than as primary authors. This was also observed in all the other fields covered in previous essays.[2-4] The lone exception in the present study is neurobiology. But only two authors are included here, and one of them (E.G. Jones) received nearly twice as many primary author citations as secondary author citations. If a larger group of neurobiologists had been included, I suspect that the typical pattern would apply.

Six of the 281 authors in this part are Nobel laureates. They are indicated by an asterisk in Table 1. Two endocrinologists, two pharmacologists, and two oncologists have won the Nobel prize. All six are also members of national academies. Academy memberships are denoted by letters in column H of Table 1. A

Table 3: Discipline averages for authors 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
Oncology	48	4065	1155	2910	134	30	104	16	2	1926
Cardiology	33	4439	1018	3421	167	35	133	4	—	1930
Gastroenterology	10	3980	992	2988	167	31	136	1	—	1929
Nephrology	1	3012	643	2369	120	9	111	—	—	1928
Nuclear Medicine	1	4454	403	4051	304	33	271	—	—	1927
Pathology	23	3193	1172	2021	118	36	82	3	—	1927
Psychiatry	5	2930	1030	1900	110	32	78	—	—	1934
Endocrinology	77	3818	975	2843	120	25	95	13	2	1928
Neuropharmacology	10	4980	1718	3262	145	37	108	4	—	1932
Pharmacology	57	4275	1470	2804	134	44	90	12	2	1930
Neurobiology	2	2560	1288	1272	74	38	36	—	—	1940
Surgery	1	2535	1085	1450	87	20	67	—	—	1935
Neurology	13	3667	1269	2398	119	39	80	5	—	1928

key to these letter codes appears in Table 2. Only 58 authors are academy members. This includes four authors on the list elected to the US National Academy of Sciences after the list was prepared: T. Sugimura and E.D. Thomas, oncology; E. Costa, neuropharmacology; and A.H. Conney, pharmacology. Taken as a group, the average age of academy members is 59 years, and 52 years for nonmembers. Of the 58 academy members listed here, 31 are members of one academy, 16 of two, and nine of three academies. Both R. Dulbecco, oncology, and J. Axelrod, pharmacology, are members of four national academies.

Richard Wurtman, Massachusetts Institute of Technology, informed us that he and several other authors on the list worked with Axelrod at the National Institute of Mental Health (NIMH) from 1963 to 1965.[6] S. Snyder, J. Glowinski, L. Iversen, and Wurtman were fellows in Axelrod's laboratory of clinical science, section on pharmacology.[6] It's an interesting coincidence that this study is based on citation data for articles published by these authors since they left Axelrod's lab at NIMH. This "invisible college" of Axelrod's fellows has done quite well since then. It would be interesting to "map" patterns of citations between former research collaborators. We might see these invisible colleges continuing over time, even though the collaborators are no longer at the same laboratory or institution.

Table 3 presents average citation and authorship data for the entire group of scientists under each discipline heading. However, data presented for nephrology, nuclear medicine, and surgery are absolute numbers, since each of these disciplines is represented by only a single author. The cardiologists and gastroenterologists have the highest average of cited papers per author, 167, while the neuropharmacologists have the highest average of citations per author, 4,980. The oncologists, cardiologists, and pharmacologists also averaged more than 4,000 citations. The oncologists are the oldest authors, with an average age of 56 years. The two neurobiologists are the youngest, averaging 42 years.

When we calculate average citations per author, 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* total of citations it received. Derek J. de Solla Price, Yale University, suggested in a letter to *Science* that *proportional* credit should be given to each author instead of *equal* credit.[7] Thus, if a paper were written by two authors, each would get half the total citations it received; three authors would get one-third each, and so on.

We recalculated citations to multiauthored papers using Price's method to see what effect it would have on our group of authors. We found that 78 of the 281 scientists in the present study would not

have made the list: 28 from endocrinology, 14 from cardiology, 12 each from oncology and pharmacology, four from pathology, and three from psychiatry. The following fields would have one less author each under Price's method of proportional citation credit: gastroenterology, nephrology, neuropharmacology, neurobiology, and surgery.

All of this indicates that we are not dealing with simple statistical problems, and that the data should be examined with extreme caution. Clearly, any of the fields that are represented by a small number of names needs to be examined more carefully. Consideration must also be given to many factors which add bias to this particular sample. When we confine citation counts to even more current literature, the average age of cited scientists *should* go down. But we've seen a number of examples where high impact appears to be age independent.

The concluding part of this study will present details on the institutional affiliations of all 1,000 most-cited contemporary authors.

* * * * *

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