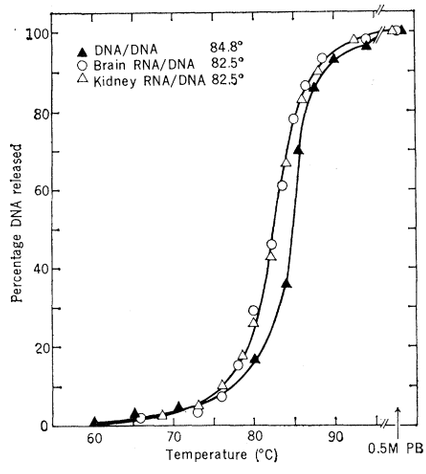

Fig. 3. Thermal denaturation of brain and kidney RNA-DNA hybrids and DNA-DNA duplexes. Melting points were obtained in 0.14*M* PB by means of stepwise temperature increases on a jacketed hydroxyapatite column. Prior to the temperature increases the column containing hybrids or duplexes was washed at 60°C with 0.14*M* sodium phosphate to free the column of nonhybridized DNA. After elution up to 94°C, the remaining 2 to 3 percent of the DNA was removed by washing with 0.5*M* PB. ▲, DNA-DNA duplexes formed with nonrepeated DNA fraction, renatured to a C_0t of 800 mole sec/liter; ○, brain RNA-DNA hybrids; △, kidney RNA-DNA hybrids. Denaturation of 100 percent corresponds to 127,000, 28,000, and 9,000 count/min of ^{3}H-labeled DNA for the respective hybrids and duplexes.

recovered from RNA-DNA hybrids formed after short-term incubation (arrow, Fig. 2A) was renatured with unlabeled, mouse DNA. No apparent reaction with the rapidly renaturing sequences was observed. Instead, this recovered DNA renatures in accordance with the kinetics expected for nonrepeated, mouse DNA. DNA recovered from hybrids formed after long-term incubation (90.5 hours) with brain RNA (Fig. 2A) also renatured with total DNA in the same manner (Fig. 2B). Therefore, we conclude that the results shown in Fig. 2A are due to reactions between RNA and nonrepeated DNA.

The stabilities of these RNA-DNA hybrids and of unique DNA-DNA duplexes were determined by thermal elution from hydroxyapatite. As the DNA becomes single stranded, it no longer binds in 0.14*M* PB (*11*). The T_m's (temperature at which 50 percent is eluted) of RNA-DNA hybrids formed with kidney or brain RNA's were 83°C, while that of DNA-DNA duplexes was 85°C (Fig. 3). Under these conditions, the T_m of native mouse DNA is about 87°C (not shown) (*12*). These high thermal stabilities indicate that extensive base pairing is present in the hybrids, as expected for association products of unique-sequence polynucleotides. These high stabilities are in contrast to those observed with most RNA-DNA hybrids involving repeated sequences. Such hybrids exhibit T_m's ranging from 68° to 75°C, depending on the reaction conditions (*8*).

Hybridization values obtained with preparations of DNA and nuclear RNA (Table 1) indicate that RNA's complementary to at least 8 to 12 percent of mouse unique DNA are present in mouse brain. If only one of the complementary DNA strands is transcribed, this represents about 20 percent of the potential information in nonrepeated DNA, or 12 percent of that in the total genome. This preliminary estimate of gene activity in mouse brain represents the equivalent of more than 300,000 different sequences of 1,000 nucleotides each. While it is likely that these sequences are functionally as well as structurally diverse, we wish to emphasize that nonrepeatedness (or uniqueness), as defined by our experimental conditions, does not imply absolute lack of relationship of such sequences. However, based on the temperature and salt restrictions, we estimate that these "unique" polynucleotides differ from each other sequentially in at *least* 20 to 30 percent of their nucleotides (*12*).

The brain may be considered to be several organs in one. Considering this complexity on the basis of the variety of neuronal and glial cell populations in various areas, it is perhaps not surprising that the range of genetic activity in the entire brain is much greater than in organs such as the liver and kidney.

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Sex and Population Differences in the Incidence of a Plasma Cholinesterase Variant

Abstract. *Accumulating knowledge of polymorphic enzyme systems poses intriguing possibilities of anthropologic genetics. Development of an automated procedure for determination of heterozygosity or homozygosity of the atypical plasma cholinesterase allele (E_1^a) permitted screening of 2317 individuals during a national Preschool Nutrition Survey and several smaller population studies. Frequencies of the allele (E_1^a) closely parallel those previously reported. Caucasians manifested a heterozygote male preponderance of 1.85 : 1.*

The plasma cholinesterase enzyme system is a polymorphic one with multiple alleles and isoenzymes (*1*). At this time, three alleles have been described based upon inhibition studies: the usual enzymatic form (E_1^u), the atypical allele (E_1^a), and the fluoride-resistant allele (E_1^f). When the enzyme has been subjected to electrophoresis, four isoenzymes (C_1, C_2, C_3, C_4) are usually observed. Recent investigators report successful demonstration of one to three additional isoenzymes (C_5, C_6, C_7) (*2*), and one investigator has demonstrated a total of 12 (C_1–C_{12}) in human serums (*3*). The atypical allele is inherited as an autosomal recessive. The homozygous atypical condition predisposes to prolonged apneic periods and muscular paralysis following ad-

Table 1. Frequency of plasma pseudocholinesterase E_1^a allele in U.S. preschool children.

Population studies	Total sample	Phenotype			Frequency of E_1^a allele
		$E_1^uE_1^u$	$E_1^uE_1^a$	$E_1^aE_1^a$	
Preschool Nutrition Survey	1841	1792	50	2	0.0146
Caucasian	1494	1446	49	2	.0177
Male	771	741	31	2	.0226
Female	723	705	18	0	.0124
Negro	347	346	1	0	.0014
Male	179	178	1	0	.0027
Female	168	168	0	0	0
White Mountain Apache Indian	111	111	0	0	0
Male	61	61	0	0	0
Female	50	50	0	0	0
San Ysidro Mexican-American	105	99	6	0	0.0285
Male	58	55	3	0	.0258
Female	47	44	3	0	.0319
Mississippi pilot study					
Caucasian	142	134	8	0	0.0281
Male	71	65	6	0	.0422
Female	71	69	2	0	.0140
Negro	118	118	0	0	0
Male	51	51	0	0	0
Female	67	67	0	0	0

ministration of the muscle relaxant succinylcholine (*4*). Although reported studies of plasma cholinesterase activity in various disease states date from the 1930's, no pathophysiological condition has been attributed to the heterozygous state (*5*).

Recently, a population-genetic study on plasma cholinesterase has been completed in conjunction with the national Preschool Nutrition Survey (*6*). Samples were obtained from 1841 noninstitutionalized children between the ages of 1 and 6. Selection was adapted for cross-sectional representation of the total U.S. population (*7*) and provided an opportunity for one of the first such genetic studies performed prospectively in the United States.

An automated screening procedure, based on enzyme activity differences of the plasma cholinesterase variants in

Table 2. Frequency of plasma pseudocholinesterase allele E_1^a in various populations.

Population studies	Year	Total sample	Phenotype			Frequency of E_1^a allele	Investigators
			$E_1^uE_1^u$	$E_1^uE_1^a$	$E_1^aE_1^a$		
African							
Berber		55	53	2	0	0.0182	Kattamis *et al.* (*9*)
Moroccan Jewish		51	50	1	0	.0098	Kattamis *et al.* (*9*)
Negroes-Congolese		585	584	1	0	.0009	Kattamis *et al.* (*9*)
North Africans		106	103	3	0	.0142	Kattamis *et al.* (*9*)
Asian							
Formosan Chinese		340	339	1	0	0.0015	Morrow and Motulsky (*10*)
Japanese	1965	371	371	0	0	0	Omoto and Goedde (*11*); Altland *et al.* (*12*)
Japanese	1965	140	140	0	0	0	Morrow and Motulsky (*10*)
"Oriental" population of unstated origin (mostly Japanese)		426	422	4	0	.0047	Morrow and Motulsky (*10*)
Filipinos	1965	411	409	2	0	.0024	Morrow and Motulsky (*10*)
Australians	1963	98	97	1	0	0.0051	Horsfall *et al.* (*13*)
Eurasian							
Czechoslovakians	1963	168	168	12	0	0.0333	Goedde and Altland (*14*); Goedde *et al.* (*15*)
Greeks		360	347	13	0	.0181	Kattamis *et al.* (*9*)
Greeks	1965	561	545	16	0	.0143	Morrow and Motulsky (*10*)
Greeks*	1969	860	727	14	0	.0081	Fraser *et al.* (*16*)
Israelites	1963	433	406	27	0	.0312	Szeinberg (*17*)
Lebanese	1968	1315	1272	42	1	.0167	Loiselet and Srouji (*18*)
Turkish	1967						Sayek *et al.* (*19*)
European							
British	1962	703	676	27	0	0.0192	Kattamis *et al.* (*9*)
German	1963	8314	8047	264	3	.0162	Goedde and Altland (*14*); Goedde *et al.* (*15*)
Portuguese	1962	179	173	6	0	.0168	Kattamis *et al.* (*9*)
North American							
Aleuts		58	58	0	0	0	Gutsche *et al.* (*20*)
Athabascan Indians		414	141	0	0	0	Gutsche *et al.* (*20*)
Canadians	1958	2017	1942	74	1	0.0188	Kalow and Gunn (*21*)
Caucasian Americans	1965	246	238	8	0	.0163	Morrow and Motulsky (*10*)
Eskimos		145	145	0	0	0	Morrow and Motulsky (*10*)
Eskimos (Northern)	1967	122	122	0	0	0	Gutsche *et al.* (*20*)
Negroes—Seattle		666	659	7	0	.0053	Morrow and Motulsky (*10*)
"Other" ethnic groups—Alaska		33	33	0	0	0	Gutsche *et al.* (*20*)
South American							
Brazilians	1965	2076	2076	60	2	0.0149	Simpson and Kalow (*22*)
Indian (Mexican) tribes	1964	370	370	7	0	.0093	Lisker *et al.* (*23*)
Three South American Indian populations	1967	291	291	0	0	0	Arends *et al.* (*24*)

* 119 unknown.

tris and phosphate buffers, enabled easy identification of the heterozygous and homozygous atypical enzymes (*8*). When 2.0 m*M* butyrylthiocholine iodide is used as substrate, the homozygous usual enzyme will demonstrate the same activity whether assayed in 0.05*M* tris or 0.05*M* phosphate buffer. The heterozygous and homozygous atypical enzymes will show approximately 13 and 42 percent less activity, respectively, in phosphate buffer as compared to tris buffer.

When the national sample was subdivided according to race (see Table 1), it was seen that only 1 of 347 Negroes examined was found to be heterozygous for the atypical plasma cholinesterase enzyme and none were homozygous atypical. This incidence (0.29 percent) reaffirmed the previously reported low incidence of plasma cholinesterase abnormality in Negro populations. The one heterozygote detected may represent Caucasian admixture in a family for which detailed pedigree information was unavailable.

In 1494 Caucasian children examined in the national Preschool Nutrition Survey, 31 boys and 18 girls were found to be heterozygous for the atypical plasma cholinesterase enzyme and 2 boys were identified as homozygous atypical. By chi-square analysis, this sex-related difference in incidence of heterozygosity among Caucasian children was not significant ($\chi^2 = 2.28$; d.f. $= 1$; $.2 > P > .1$). The one heterozygote detected among Negro children was also a male. The incidence figures from this survey were comparable to those reported by other investigators in which 3 to 8 percent of study populations were found to be heterozygous for a gene specifying an atypical cholinesterase in the serum and roughly 0.10 to 0.50 percent were homozygotes for this gene (see Table 2) (*9–24*). No individuals homozygous for the silent allele (E_1^s), a phenotypic variant reportedly occurring less than once in 3000 in other populations, were detected in some 2500 individuals examined to date. Assessment of the described fluoride-resistant allele was not performed.

Population studies generally have failed to report phenotypic information according to sex. A few investigators have noted a similar sex-related difference which was believed to be nonsignificant statistically (*9–24*). In a 1958 study, Kalow and Gunn (*21*) reported a 2.54 percent male:2.18 percent female incidence of the heterozygous state ($P > .05$). No information on sex of the homozygous atypicals was stated. Fraser *et al.* (*16*), studying individuals in two villages of northwestern Greece, reported a sex difference in E_1^a gene frequency of 0.012 male : 0.007 female.

No sex linkage is believed to exist in the genetic inheritance for atypical plasma cholinesterase gene. The following points support the possibilities of sex modification and environmental influence upon this polymorphic system: (i) the incidence of heterozygosity in males almost twice that in females in our preschool survey population, (ii) no reported significant sex difference in the primarily adult populations which have been studied (*9–24*), (iii) preliminary pedigree studies in families of heterozygous or homozygous children detected in our survey suggesting an increased incidence of miscarriages in mothers of affected children.

In addition to the national survey, several smaller population groups were also investigated for the relative incidence of the heterozygous and homozygous atypical phenotypes (see Table 1). A pilot study (*25*), completed in April 1968, was adapted for cross-sectional (geography and race) representation of the population in Mississippi. Plasma samples were originally collected from 410 children and plasma cholinesterase assays were completed on samples (260) still available in 1970. Of Caucasians studied in Mississippi, 5.63 percent were heterozygotes (6 males and 2 females), giving a 3 : 1 male : female sex incidence, which was not statistically significant because of the small numbers involved. If the Caucasians examined in the Mississippi pilot study are added to the national sampling, the sex-related difference becomes significant ($\chi^2 = 3.72$; d.f. $= 1$; $P < .05$). All 118 Mississippi Negroes studied were noted to have the usual phenotype.

Two additional small populations of southwestern U.S. preschool children, one Mexican-American and one Apache Indian, were studied, but sampling could not be considered representative of any larger population group (see Table 1). In Mexican-American preschoolers from San Ysidro, California, 5.71 percent of 105 children were homozygotes (3 males, 3 females), and no heterozygotes for atypical or silent genes were detected. No male sex preponderance was evident in this population. In 111 White Mountain Apache preschool children, neither heterozygotes nor homozygote atypicals were detected. The absence of the atypical gene in this Indian population group paralleled other Indian populations in which the gene was also absent or extremely rare (see Table 2).

Frequencies of the atypical allele among world populations have been stated to be remarkably similar. This similarity is true of European and Mediterranean populations. As more areas of the world including populations of diverse origin have been surveyed, an interesting pattern has evolved. The allele is presumably absent in Japanese, Eskimos, and South American Indians. It is rare in Negroes, Australian aborigines, Filipinos, and Oriental populations (other than Japanese) studied, and in those cases reported, the degree of racial admixture is not known. Explanation of this consistent incidence variability which is further supported by our study poses an intriguing problem for both geneticists and anthropologists.

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Informal Contacts in Science: A Probabilistic Model for Communication Processes

Abstract. *Significant contacts among scientists within research specialties are generally infrequent and are distributed as an essentially random process, the pattern of most contacts conforming to a Poisson distribution. Extremely productive persons in a specialty, however, seem to form a separate distribution; they have a considerably higher number of contacts.*

The systematic study of informal communication within science dates from Price's postulation in 1961 of the "new invisible colleges" as a social mechanism critical to the continued functioning of science as a large, diffuse, international activity (*1*). In the course of planning and initiating a program of research on communication among medical researchers, we reexamined two questions regarding invisible colleges implicit in Price's formulation, namely: (i) Do "Invisible Colleges," in the sense of small, active elites, function critically in the organization and communication network of science? (ii) Are there quantitative bases for postulating their existence?

These questions seemed largely lost from view because of the incompatibility of data from recent studies that focused on elites (*2*) with data from studies based upon exhaustive lists of the membership of individual specialties (*3, 4*). In the first type of study, the investigators principally contacted central persons in the field, and discarded other respondents. In the second studies, very general measures were taken on all persons who can be identified with a specialty, and the data showed continuous functions relating productivity, "centrality," and communication. To provide a means of reconsidering these problems, the present report proposes a model for informal contacts and communications within science that relates the concept of elites to the membership of specialties and is in line with the scale of science and the number of relatively productive persons within disciplines.

There is substantial evidence that much of science is loosely organized; Mullins' dissertation concluded that normal science operates as a loose network and that the common impression among researchers that invisible colleges exist is no more than a somewhat egocentric view of the individual scientist that persons who relate to him are a group *who, in turn, relate to one another* (the italicized portion being erroneously presumed by the scientist) (*5*). The full published report of the data on informal communication and organization in psychology strongly emphasized the wide range in degree to which specialties are organized and the relatively small size of the group of highly productive scientists, about 2000 to 4000 for even major disciplines; this report postulated that it would be no great task for an experienced researcher to get to know most of the active researchers in any one specialty within a discipline (*6*). In the recent Nelson and Pollack conference volume were chapters by Hagstrom and by Griffith and Miller speculating that the normal size of most scientific specialties is extremely small (*2, 7*). Further considerations for developing a model for network structure were recently furnished by Crawford and Crane, who established strong relationships among position in communication networks, scientific productivity, and direction of information flow (*3, 4*). More central persons were found to be more productive; are more frequently sought out by others, less central, who wish to obtain information; and directed most of their self-initiated communication activities to other central persons.

These static pictures of specialties have taken little account of the relatively fast rate at which the personnel of science renews itself, principally through new persons completing graduate training, or of certain intellectual attributes on which scientific specialties differ (*8*). Thus, there are always "unknowns" entering an active research specialty, who are probably aware of the more productive members of the specialty but who can only become "known" after some period of productivity. In addition to the recruitment of younger researchers, there is a continual movement of researchers among specialties as a function of the transferability of skills and knowledge. The Poisson distribution is given by:

$$p = e^{-\lambda}\frac{\lambda^k}{k!}$$

where p is the probability of k successes per observation where the overall average number of successes is λ (*9*). The published distribution of contacts in Crane's data (see *3*) suggested the Poisson, and since the probability of trials yielding zero successes is given by $e^{-\lambda}$, we used the number of persons receiving zero nominations to solve for λ. The obtained value of λ was .78, and the resultant fit was at least suggestive. This value of λ for the average number of contacts per researcher seemed to us to be no more than we would expect throughout the active