Table 1. Effect of warfarin on localization of colony-forming units in regenerating liver. All cells were intravenously injected within 3 hours following 900 rad of whole-body x-irradiation of recipients.

Mice in recipient group (No.)	Time of killing after injection of cells (days)	Treatment of donors	Nodules per spleen of recipients (Mean ± S.E.)
		Liver cells injected (20 mg)	
13	7	None	0.31 ± .17
14	7	CCl_4	2.64 ± .41
12	7	CCl_4 + warfarin	0.42 ± .23
13	7	Warfarin	.31 ± .14
4	10	Untreated	.50 ± .29
6	10	CCl_4	3.67 ± .16
5	10	CCl_4 + warfarin	0.40 ± .24
6	10	CCl_4 + warfarin + vitamin K	2.83 ± .54
5	10	Warfarin	0.20 ± .20
		6×10^4 Bone marrow cells	
4	10	Untreated	11.75 ± .63
6	10	Warfarin	12.33 ± .71

cell injection. Recipient mice injected intravenously with bone marrow cells did not require prior injection with heparin. At the same time that the liver slices were taken, bone marrow cells were taken from washings of the femur with culture medium. Cells were counted and diluted in culture medium to a count of 6×10^4 cells for each intravenous dose of 0.2 ml.

Recipient mice were killed at 7 and 10 days after intravenous injection of cells, spleens were removed intact and placed in formalin–acetic acid, and nodules were counted macroscopically before sectioning.

As measured by the production of macroscopic nodules in the spleens of lethally irradiated mice, the intravenous inoculum of liver cells from mice previously injected with carbon tetrachloride contains approximately eight times as many colony-forming units as control liver cells do (Table 1). The administration of warfarin prevents the increase in colony-forming units in livers injured by CCl_4; concurrent administration of vitamin K restores the increase in the number of colony-forming units in mice treated with warfarin and CCl_4. The effect of warfarin is probably due to its inhibition of fibrin formation in the livers of mice treated with CCl_4, which suppresses the trapping of colony-forming units from the circulating blood leukocytes. Bone marrow cells from warfarin-treated mice contain the same number of colony-forming units as bone marrow cells from control mice.

Our results suggest that extramedullary hemopoiesis, rather than resulting from a transformation and differentiation of primordial cells originally located in extramedullary tissue, occurs when hemopoietic progenitor cells, derived from the bone marrow and circulating in the peripheral blood, localize in extramedullary tissue such as liver. These hemopoietic stem-cell elements, in common with metastatic tumor cells, may require the deposition of fibrin to establish themselves in tissue. The question arises whether the localization and establishment of hemopoietic colony-forming units in "normal" sites of extramedullary hemopoiesis, such as the spleen, can be adversely affected by anticoagulants.

Note added in proof: In cytogenetic studies (*18*) on regenerating liver (after CCl_4 administration) of radiation-chimeric mice, 89 percent of the cells (from 11 chimeras) in mitosis (presumably the cells were parenchymal) were identified as donor type, derived from the injected spleen cells. In view of our results and those of Nowell *et al.* (*17*), it seems likely that at least some of the T6-containing cells in liver observed by Hard and Kullgren (*18*) may in fact be hemopoietic colony-forming units of extra-hepatic origin.

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References

1. R. Hiramoto, J. Bernecky, J. Jurandowski, D. Pressman, *Cancer Res.* **20**, 592 (1960).
2. R. A. Q. O'Meara, *Irish J. Med. Sci.* **6**, 474 (1958).
3. W. F. Bale, I. L. Spar, R. L. Goodland, *Cancer Res.* **20**, 1488 (1960).
4. I. L. Spar, W. F. Bale, R. L. Goodland, M. J. Izzo, *ibid.* **24**, 286 (1964).
5. C. E. Grossi, D. Agostino, E. E. Cliffton, *ibid.* **20**, 605 (1960).
6. E. E. Cliffton and D. Agostino, *ibid.* **15**, 276 (1962).
7. ———, *Vascular Dis.* **2**, 43 (1965).
8. J. W. Alexander and W. A. Altemeier, *Ann. Surg.* **159**, 933 (1964).
9. D. Agostino and E. E. Cliffton, *ibid.* **161**, 97 (1965).
10. ———, *Cancer Res.* **25**, 1728 (1965).
11. J. E. Till and E. A. McCulloch, *Radiation Res.* **14**, 213 (1961).
12. L. Siminovitch, E. A. McCulloch, J. E. Till, *J. Cell. Comp. Physiol.* **62**, 327 (1963).
13. J. E. Till, E. A. McCulloch, L. Siminovitch, *Proc. Nat. Acad. Sci. U.S.* **51**, 29 (1964).
14. W. R. Bruce and E. A. McCulloch, *Blood* **23**, **216** (1964).
15. C. W. Gurney and W. Fried, *Proc. Nat. Acad. Sci. U.S.* **54**, 1148 (1965).
16. L. J. Cole, *Am. J. Physiol.* **204**, 265 (1963).
17. P. C. Nowell, D. E. Craig, F. A. Matthews, L. J. Cole, *Radiation Res.* **24**, 108 (1965).
18. R. C. Hard, Jr., and B. Kullgren, *Science* **152**, 349 (1966).

7 April 1966

Chainpur-like Chondrites: Primitive Precursors of Ordinary Chondrites?

Abstract. *Chainpur and similar, apparently primitive, chondritic meteorites may be precursors of ordinary chondrites; a variety of evidence supports this working hypothesis. In general, carbonaceous chondrites seem to be related collaterally to this genetic sequence rather than being direct ancestors of ordinary chondrites. Metamorphic processes may be responsible for fractionations of elements such as indium and iodine, and type-II carbonaceous chondrites seem to be more primitive than types I or IIIA.*

A long-standing problem has been an adequate and self-consistent explanation of the observed properties of chondritic meteorites (*1, 2*). Chondrites comprise about 85 percent of observed meteoritic falls (*3*); they divide into various classes, notably carbonaceous chondrites, enstatite chondrites, and ordinary chondrites. Each of these major classes may be separated into subclasses—for example, the ordinary chondrites are generally subdivided into the Fe-rich group, the Fe-poor group, and Soko-Banjites (*4, 5, 6*). We now consider evidence bearing on the relations among the ordinary and carbonaceous chondritic classes (*7*).

The ordinary chondrites are quite homogeneous in composition in most "nonvolatile" elements, the most prominent exception being the total content of Fe (*2, 4*). The average metal content of the Fe-rich group exceeds that of the Fe-poor group by about 9 or 10 percent; FeO contents of the ferromagnesian silicates of these meteorites vary less, in the opposite sense. Recent comprehensive studies (*6, 8*) suggest that addition of roughly 6 percent metal to Fe-poor chondrites and reduction of some FeO to Fe could have produced Fe-rich chondrites, the silicate phases of these meteorites having essentially the same composition (FeO content excluded). Of course, the process of metal transport coupled with oxidation, or reduction, could have occurred in the other direction, making Fe-poor chondrites from material of Fe-rich–group composition (*6*).

Also, the sequence of events may well have been much more complicated than this simple model suggests. In any case, the materials implicated were probably chemically similar (in a gross sense) to those we observe now but physically quite different. The important point is that ordinary chondrites may in principle be related to each other by relatively simple chemical-differentiation processes.

It has also been suggested that at least some ordinary chondrites seem to be related one to another, within each subclass, by consistent physical changes which, if they were observed in terrestrial rocks, would probably be assigned a metamorphic origin (*9*). Thus ordinary chondrites in general may possibly prove to be genetically related to each other in a simple way.

One may consider whether there is evidence tending to link ordinary chondrites with other classes or subclasses of chondritic meteorites. If a plausible argument for the existence of such a relation could be constructed, it might be possible to place almost all stone meteorites in a well-defined genetic sequence. Various suggestions have been offered regarding the precursors of ordinary chondrites: Type I carbonaceous chondrites, with Orgueil the usual prototype, have frequently been alleged to be the most primitive of meteorites and the precursors of all others (*10*). The unique type-II carbonaceous chondrite Renazzo has served as the foundation for an ingenious model of chondritic evolution; the type-IIIB chondrite Tieschitz also has been considered an example of a primitive chondrite (*11*). We have recently considered the possibility that type-II carbonaceous chondrites are in general more primitive than other carbonaceous chondrites and may be ancestral to them, but it seems unnecessarily speculative at present to try to link ordinary chondrites with the type-II subclass.

Dodd and Van Schmus (*9*) suggest that the meteorites Chainpur, Barratta, and Bishunpur (among others) may be classified as relatively highly disequilibrated members of the Fe-poor group; the basis is petrographic criteria and such chemical evidence as the range of variations of major-element composition in mineral grains of these meteorites. Relying largely on elemental abundances determined by instrumental neutron-activation analyses over the entire spectrum of chondritic classes, we have placed these meteorites (also Ngawi and Tieschitz) in a separate subclass, type IIIB (*12*). We have also suggested [as has Wood (*13*)] that they represent precursors of recrystallized Fe-poor chondrites, entirely independently of the arguments of Dodd and Van Schmus. As a working hypothesis, we now propose that type-IIIB chondrites, with Chainpur as a type specimen for the present, are the precursors of ordinary chondrites (all subclasses) and that they should be regarded as comparatively primitive. The following observations support this hypothesis:

1) Chainpur has minerals and chondrules zoned or heterogeneous (or both), and glass is observed in the chondrules (*9, 14*). These properties imply that this meteorite has not been strongly reheated late in its history.

2) Major and minor elemental abundances of Na, Si, Mg, Al, Sc, Cr, Mn, Fe, Co, and Cu in Barratta, Bishunpur (Co excepted), Chainpur, Ngawi, and Tieschitz (Fe and Co excepted) are strikingly similar to those found in the Fe-poor group of chondrites and the Soko-Banjites (*12, 15*). The great Fe and Co abundances in Tieschitz are similar to those found in the Fe-rich group of chondrites. Thus metamorphism of type-IIIB chondrites into their analogs among ordinary chondrites would not entail large-scale chemical modifications. This observation is especially pertinent in terms of the Mg: Si ratios that are systematically different when ordinary chondrites are compared with most carbonaceous chondrites (*16*); in this sense, Chainpur, though carbonaceous, resembles the ordinary chondrites. Urey (*17*) has pointed out that, depending on whether CO or CO_2 is formed, reduction of FeO by the carbon present in Chainpur would lead to a metallic-Fe content of between 5.7 and 8.3 percent, leaving between 12.9 and 9.5 percent FeO in the silicates; such composition would be in reasonable agreement with the averages of the Fe-poor group of chondrites or the Soko-Banjites.

3) Indium abundances have recently been determined in several carbonaceous (*18, 19*) and ordinary chondrites (*18*); the element is one that is markedly more abundant in carbonaceous than in ordinary chondrites—which observations have led to several attempts to devise models of geochemical processes that may have given rise to these fractionations (*2, 20*). According to our recent results Chainpur contains In: Si (atoms) at $0.10 \pm 0.01{:}10^6$; this ratio equals the average observed atomic abundance of In in Mighei (type II) and is comparable with the average observed ratios in Orgueil (type I; $0.21{:}10^6$), Lancé (type IIIA; $0.05{:}10^6$), and the enstatite chondrite Abee ($0.12{:}10^6$). Indium is about 250 times less abundant in ordinary chondrites than in Chainpur of Mighei (our analyses of five ordinary chondrites yielded an average In:Si ratio of $0.0004 \pm 0.0002{:}10^6$). We believe that this chemical fractionation was indeed a depletion of In in ordinary chondrites, and that Chainpur is therefore more primitive than ordinary chondrites. It is interesting that the Suess-Urey abundance estimate (In:Si) of $0.11{:}10^6$ (*21*) is in excellent agreement with our results on Chainpur, Mighei, and Abee; their estimate was derived from examination of abundances and isotopic ratios of neighbors of In in the periodic table—not from analytical data on In in meteorites or in the sun. Thus the concordance of In atomic abundances in three different kinds of chondritic meteorites, among themselves and with the Suess-Urey estimate, is clearly significant.

4) Abundances of Cl, Br, and I in a number of chondrites have been determined (*22*). While these elements are fractionated between ordinary and carbonaceous chondrites less strikingly than In, the data indicate that Chainpur resembles carbonaceous (and enstatite) chondrites more than ordinary chondrites in its halogen contents. Of particular interest are the I data: the Chainpur content is 200 ppb (parts per billion), which is more than 10 times greater than the highest value for ordinary chondrites (*22*) and about 3 times greater than the highest value found for ordinary chondrites other than Ergheo and Ställdalen (*23*). The Chainpur value lies comfortably within the range determined for carbonaceous chondrites. Thus, if iodine is depleted in ordinary chondrites but not in carbonaceous chondrites, Chainpur has not been subjected to this depletion and thus may be considered more primitive than ordinary chondrites.

5) Ranges of the dispersions in Mn-abundance histograms for chondrule batches from types II, IIIA, and IIIB (specifically, Chainpur) carbonaceous chondrites are very similar (*24*). This similarity implies similar thermal histories for chondrules from these subclasses, and in particular that there has been little or no thermal metamorphism of these meteorites (since dispersions of Mn abundances in such chondrule batches decrease markedly in

recrystallized chondrites). Chainpur is as primitive as any type II or IIIA chondrite by this criterion.

6) Fractionation patterns of the 14 rare-earth elements (REE) are almost identical in chondrules of Chainpur and Mokioa (type IIIA); the patterns are defined relative to the uniform REE distribution in 20 ordinary chondrites (*25*). Normalizing to Yb abundances, we find that REE in both Chainpur and Mokoia chondrules have been linearly fractionated, in the sense of a small depletion of the light REE, when their distributions are compared with the standard. The depletion seems to be ≤20 percent for La, which is probably beyond experimental error. Absolute abundances of the REE in Chainpur chondrules agree well with those in ordinary chondrites. In chondrules of the ordinary (and recrystallized) chondrites Allegan and Richardton, however, the REE have been distinctly and linearly fractionated—to the extent of about 50 percent for La when similarly normalized to Yb. We believe that these observations strongly imply that both Chainpur and Mokoia are more primitive than Allegan and Richardton.

These observations all point to the same conclusions: that Chainpur and its congeners are closely related to ordinary chondrites, but that they have various highly significant primitive traits. In several instances Chainpur-like or type-IIIB chondrites clearly are as primitive as any other class or subclass of chondrites by reasonable and well-defined criteria. We believe that this fact lends plausibility to the hypothesis that Chainpur-like chondrites are in some sense the precursors of ordinary chondrites; and that they represent a link between ordinary chondrites [which in general are relatively highly recrystallized (*26*)] and materials related in some more direct way to bodies accreting from the primeval solar nebula. Both the observation of chondrites apparently as primitive as the type-IIIB subgroup (but chemically quite distinct) and the fractionation of Fe emphasized by Urey (*2*) imply that far-reaching compositional changes may well have occurred during or after the accretion process. We emphasize our belief that such compositional changes have affected all known meteorites, including the various subgroups of the carbonaceous chondrites.

In our view, carbonaceous chondrites of types I, II, and IIIA represent a *collateral*—not a *directly ancestral*—branch (or branches) to type-IIIB chondrites. Types I, II, and IIIA do not seem to display metamorphic sequences similar to those of the ordinary chondrites (*9*) or enstatite chondrites (*27*); they show unmistakable fractionation of alkali metals among these subclasses, and no clear indication of fractionation of these elements was observed in the type-IIIB or ordinary chondrites (*12*). The three types seem to have been formed in a much wetter environment than were the other chondrites. These facts might be explained by hypothesizing that type I, II, and IIIA chondrites evolved either in a much smaller parent body or in a cooler and wetter region of a complex parent body than did type IIIB (Chainpur-like) and ordinary chondrites. In any case, we argue that the parent materials of each of these two families of chondrites were noticeably different but, according to present evidence, *equally primitive* in their relation to the primeval nebula. One should note that these relationships almost certainly were so complex that "primitive" should be applied with great caution, even in the restricted sense in which we have defined the term.

Recent evidence is that type-II carbonaceous may be more primitive than type-IIIB chondrites; Wood (*27*) observes that the type-II chondrites contain much oxidized nickel in the sulfides and silicate minerals, while in the prototype Chainpur (type IIIB) and ordinary chondrites nearly all nickel occurs in the metallic phase. In the presence of a metallic phase, a slight degree of metamorphism may induce sharp changes in the nickel distribution: from the oxidized state in the sulfide and silicate phases to the reduced-nickel state in the metallic phase, which is its equilibrium state. If the nickel distribution were more sensitive to mild metamorphism than were the other observed primitive properties already discussed, such a criterion could indicate that type-IIIB chondrites have been subjected to slightly more metamorphism than have type-II carbonaceous chondrites—and to much less than ordinary chondrites. This conclusion does not apear inconsistent with either hypothesis: that Chainpur-like chondrites may have evolved in a larger parent body than did type-II carbonaceous chondrites; that type IIIB chondrites may have metamorphosed (*27*) in another parent body at greater depths than type-II carbonaceous chondrites.

Two important inferences derive from our working hypothesis that Chainpur-like chondrites were primitive precursors of ordinary chondrites: First, if the primitive precursors indeed contained "normal" amounts of many of the sensitive trace elements that are depleted in their recrystallized and equilibrated descendants, perhaps the recrystallization process itself should be examined, rather than the processes leading to accretion from the primeval nebula, in order to construct models of the fractionation of these elements. [Data on enstatite chondrites lead to a congruent inference (*28, 29*).] Simple metamorphism may have depleted some sensitive trace elements (*10, 13*).

Second, if the In atomic abundance of Chainpur (and Abee) is truly representative of primordial nonvolatile abundances, then type-II carbonaceous chondrites may well be more primitive than either type I (in which the In atomic abundance seems to be twice that in Chainpur or Abee) or type IIIA (in which In seems to be half that in Chainpur or Abee). Thus one is led to question the alleged highly primitive character of type-I carbonaceous chondrites, and perhaps to examine possible models for derivation of types I and IIIA from material like type II.

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References and Notes

1. G. Tschermak, *Sitzber. Akad. Wiss. Wien Math.-naturw. Kl.* **71**, 661 (1875); H. C. Sorby, *Nature* **15**, 495 (1877); G. P. Merrill, *Smithsonian Inst. Sci. Ser.* **3** (pt. 1), 1 (1929); W. Campbell Smith, *Advan. Sci.* **26**, 1 (1950); E. Anders, *Space Sci. Rev.* **3**, 583 (1964).
2. H. C. Urey, *Rev. Geophys.* **2**, 1 (1964).
3. B. Mason, *Meteorites* (Wiley, New York, 1962), chap. 6, pp. 70–103 (especially p. 70).
4. H. C. Urey and H. Craig, *Geochim. Cosmochim. Acta* **4**, 36 (1953); H. Craig, in *Isotopic and Cosmic Chemistry*, H. Craig, S. L. Miller, G. J. Wasserburg, Eds. (North-Holland, Amsterdam, 1964), pp. 401–51.
5. B. Mason and H. Wiik, *Geochim. Cosmochim. Acta* **28**, 533 (1963).
6. B. Mason, *Amer. Museum Novitates No. 2223* (August 1965), 38 pp.
7. The carbonaceous-chondrite subclasses include: Alais, Ivuna, Orgueil, and Tonk (type I); Al Rais, Bells, Boriskino, Cresent, Cold Bokkeveld, Erakot, Haripura, Mighei, Murray, Nawapali, Nogaya, Pollen, Renazzo, and Santa Cruz (type II); Felix, Groznaja, Kaba, Karoonda, Lancé, Mokoia, Ornans, Vigarano, and Warrenton (type IIIA); and Bishunpur, Chainpur, Ngawi, Tieschitz, and very probably Mezö-Madaras and others (type IIIB).
8. L. Greenland and J. F. Lovering, *Geochim. Cosmochim. Acta* **29**, 821 (1965).

9. R. T. Dodd, Jr., and R. Van Schmus, *J. Geophys. Res.* **70**, 3801 (1965); R. Van Schmus and R. T. Dodd, Jr., personal communication.
10. See, for example, A. E. Ringwood, *Geochim. Cosmochim. Acta* **24**, 159 (1961). "Precursors" in this sense, and throughout this paper, refers to materials thought to be physically and chemically similar to those from which less-primitive chondrites derived. The true parental material has, of course, been altered. In using the comparative term "primitive" we mean only that a given meteorite (or group of meteorites) seems to have escaped the effects of a physical or chemical process that left discernible imprints on "less primitive" meteorites: for instance, the presence of glass and clinopyroxene (both believed to be unstable under mild reheating) in a meteorite implies that it was not reheated late in its history; the presence of plagioclase exsolution lamellae in orthopyroxene grains, or of devitrified glass, may mean that a meteorite was reheated late in its history. Thus we would tentatively refer to the first as "primitive" and to the second as "less primitive." Neither "primitive" nor "precursor" implies anything regarding the ultimate origin of chondrites.

→ J. A. Wood, *Icarus* **2**, 152 (1963); *Geochim. Cosmochim. Acta* **26**, 739 (1962); *Nature* **194**, 127 (1962).

12. R. A. Schmitt and R. H. Smith, "Abundances of Na, Sc, Cr, Mn, Fe, Co, and Cu (Na-Cu) in 11 carbonaceous chondrites; Mg in 26 ordinary chondrites; Si in 34 individual chondrules; and Na-Cu in 61 individual chondrules (Renazzo included)," *NASA Rept. GA-5900* (General Atomic Div., General Dynamics Corp. 30 Nov. 1964); "Abundances of Na, Sc, Cr, Mn, Fe, Co, Cu, and Si in chondrules and chondritic meteorites," *NASA Rept. GA-6414* (General Atomic Div., General Dynamics Corp. 31 May 1965); R. A. Schmitt, G. G. Goles, R. H. Smith, "Elemental abundances in stone meteorites," in preparation.
13. J. A. Wood, in **The Solar System**, B. Middlehurst and G. P. Kuiper, Eds. (Univ. of Chicago Press, Chicago, 1963), vol. 4, pp. 337–401.
14. K. Fredriksson and A. M. Reid, *Science* **149**, 856 (1965).
15. K. Keil, B. Mason, H. B. Wiik, K. Fredriksson, *Amer. Museum Novitates No. 2173.*
16. L. H. Ahrens, *Geochim. Cosmochim. Acta* **28**, 411 (1964).
17. H. C. Urey, personal communication.
18. R. A. Schmitt and R. H. Smith, in preparation.
19. H. Akaiwa, *J. Geophys. Res.* **71**, 1919 (1966); A. A. Smales and D. Mapper, paper presented before Intern. Congr. Pure Appl. Chem. 20th Moscow (July 1965).
20. R. A. Fish, G. G. Goles, E. Anders, *Astrophys. J.* **132**, 243 (1960); E. Anders and G. G. Goles, *J. Chem. Educ.* **38**, 58 (1961).
21. H. E. Suess and H. C. Urey, *Rev. Mod. Phys.* **28**, 53 (1956).
22. L. P. Greenland and G. G. Goles, "Abundances of chlorine, bromine and iodine in meteorites," in preparation.
23. G. G. Goles and E. Anders, *Geochim. Cosmochim. Acta* **26**, 723 (1962).
24. R. A. Schmitt, R. H. Smith, G. G. Goles, *J. Geophys. Res.* **70**, 2419 (1965); unpublished.
25. R. A. Schmitt, R. H. Smith, D. A. Olehy, in preparation; R. A. Schmitt, R. H. Smith, "Abundances of Na, Sc, Cr, Mn, Fe, Co, Cu, and the 14 rare-earth elements in chondrules," *NASA Rept. GA-6893* (General Atomic Div., General Dynamics Corp., 30 Nov. 1965); L. A. Haskins, F. A. Frey, R. A. Schmitt, R. H. Smith, in *Physics and Chemistry of the Earth* (Pergamon, New York, in press), vol. 7.
26. K. Keil and K. Fredriksson, *J. Geophys. Res.* **69**, 3487 (1964).
27. J. A. Wood, "Chondrites: their metallic minerals, thermal histories, and parent planets," in preparation.
28. K. Keil, personal communication.
29. G. G. Goles, in preparation.
30. Aided by NASA contract NASw-843 and grant NsG-319. We thank H. E. Suess, H. C. Urey, and J. A. Wood for helpful comments.

28 April 1966

Subclasses of Human Immunoglobulin A Based on Differences in the Alpha Polypeptide Chains

Abstract. *Antiserum from goats immunized with heavy polypeptide chains from a γA-type myeloma globulin was absorbed with serum from patients with selective absence of immunoglobulin A (γA). The resulting reagents could be used for the classification of 58 γA-myeloma proteins into two distinct antigenic types, respectively called subclasses He and Le. These differences were shown to be related to the heavy (alpha) polypeptide chains and independent of the integrity of interchain disulfide bridges. The γA-immunoglobulin from normal serum appears to consist, for the most part, of molecules with Le subclass specificity.*

The existence of four main classes of human immunoglobulins has gained wide acceptance. One of these, termed the γG-immunoglobulin (IgG immunoglobulin G), is by far the major antibody-carrying globulin in normal serum. The second and third members of the group, called γA- and γM-immunoglobulins (IgA and IgM), are quantitatively less important, whereas the fourth class, known as γD-immunoglobulin (IgD), exists in only trace amounts in normal serum (*1*). The differences between these four types of molecules reside in the structure of their heavy polypeptide chains, which are termed respectively γ-, α-, μ-, and δ-chains. In contrast, all classes of immunoglobulins share the same types of light polypeptide chains, of which two main varieties are known to exist, namely κ- and λ-chains. All six forms of immunoglobulin polypeptide chains occur in a seemingly infinite variety of forms, which constitute the basis of the functional and chemical specificity of antibodies and paraproteins. The γG-class of immunoglobulins may be further subdivided into at least four subclasses (termed Ne, We, Vi, and Ge, or γ_{2a}, γ_{2b}, γ_{2c}, and γ_{2d}) on the basis of structural features of the γ-polypeptide chains, most easily demonstrated by immunological techniques (*2*). Two of these subclasses (We and Vi) are the substrate for the genetical variation known as the Gm system (*3*). A search for the occurrence of similar subclasses among the other types of immunoglobulin polypeptide chains is indicated. Harboe *et al.* (*4*) reported that the γM immunoglobulins could be subdivided into two major types according to immunological characteristics of the heavy μ-polypeptide chains. We can now report that there are at least two different subclasses among the γA-immunoglobulins, based on differences in their α-polypeptide chains.

Six goats and five rabbits were immunized with a variety of antigens, namely whole normal human serum, red cells coated with salivary isoagglutinins (presumed to consist chiefly of γA-type antibodies), three purified γA-myeloma globulins, and purified α-chains from two additional γA-myeloma proteins. Only three among these antiserums proved useful in distinguishing the two subclasses of γA-immunoglobulins here described. All three antiserums were obtained from goats injected with α-chains from a single γA-myeloma protein. Although these three antiserums gave qualitatively identical results, they differed with respect to the intensity of their reactions. Most of our results here presented were obtained with an antiserum which initially reacted with many serum proteins, but could be made almost specific for γA-immunoglobulins by means of absorption with one-tenth its volume of serum from either of two patients with selective γA agammaglobulinemia. The resultant absorbed serums are called *Bm* and *Bc*.

The antiserum *Bm* was allowed to diffuse against five different γA-myeloma serums, as well as against a pool of normal serums, all diluted to approach equivalence (Fig. 1). In their precipitin patterns, two of the myeloma proteins, Wa and He, display some antigenic deficiency with respect to the three remaining myeloma proteins, Le, Ri, and Cl, as well as to the γA-immunoglobulin from pooled normal serum. Among 58 γA-myeloma serums tested, 54 reacted in the same way as Le, Ri, and Cl, that is, their precipitin lines gave a spur over the precipitin lines produced by myeloma serums He and Wa. The lines from all 54 myeloma proteins of the first group showed complete identity with each other when developed with antiserum Bm. The lines from Wa and He also completely fused with each other and with those of two γA-myeloma serums. Hereafter,