A series of collisional & dynamical processes is responsible for excavating meteorites from where they form in main-belt asteroids and delivering them to Earth. We are modeling these processes in a way that is consistent with recent ideas about the collisional evolution of asteroids, with the aim of reconciling the relative yield of meteorites of different types with what is known about the asteroids. In many elements of this problem, we adopt the perspective of earlier authors. But in several cases, the need to reconcile ideas from disparate disciplines (e.g., astronomy, geophysics, meteoritics) has forced us to adopt an unusual point-of-view. We now have an internally consistent model for the derivation of meteorites that agrees reasonably well -- although not perfectly -- with the best available evidence. Many elements of our model are not new; some departures from previous ideas are not necessarily unique requirements, although we find them difficult to avoid.

Main-belt asteroids are cratered by the smaller asteroids. We adopt effective strengths for the target asteroids that are consistent with their assumed original composition (e.g., rocky or carbonaceous) and with their inferred geophysical and collisional history. Asteroids that have been repeatedly fragmented, but not disrupted, by earlier collisions are taken to be structurally weak. Roughly 2% of the asteroids will have melted and differentiated, yielding (after spallation of their mantles and crusts) residual iron-core bodies. The largest of these we take to be the parent bodies of the pallasites and mesosiderites according to our geophysical models for the origin of stony-irons (1).

The resulting crater scaling laws and velocity distributions of escaping ejecta are then applied, based on available experimental data. The fraction of ejecta which intercepts any nearby major resonances is then converted into Earth-crossing orbits. The fraction of such fragments that survive delivery to Earth, actually encounter Earth, and survive passage through the atmosphere are the "model yields" which we then compare with statistics of meteoritic falls.

Table 1 shows the comparison of the model with the observed meteorite falls (2). Four types of meteorites are treated separately: the ordinary chondrites, the achondrites, the carbonaceous chondrites, and the metal-rich meteorites. In each case, we list the number of parent bodies of each size that are close enough to resonances to "communicate" fragments to Earth. Dividing the contributions predicted by our model into a total number of meteorites comparable to the ~700 observed falls, we arrive at the total number of falls from each communicating parent body (sometimes zero). In the case of the iron-rich meteorites (except mesosiderites), we consider, along with Wasson and Wetherill, that 1/15th of the finds constitutes a better statistical sample to compare with "Model Falls Total" than does actual falls.

In general, our model compares well with the meteorite statistics. Perhaps the worst comparison is that our model predicts that a small number of meteorites should come from one or two dozen small ordinary-chondrite-like parent bodies, contrary to observation. This conflict may be resolved if some ordinary chondrites are misclassified (3). Our model also compares well with real asteroids. According to a strict application of our model, asteroids 6, 15, 89, 354, and 532 would be dominant contributors of ordinary chondrites and achondrites, with lesser contributions from 4, 22, 29, 349, and possibly 8 and 18. Taking into account the stochastic nature of the excavation and delivery processes, the existing meteorite collection is reasonably consistent with the inferred compositions of these large asteroids.

In order to reconcile our approach with available constraints, we have
had to incorporate the following innovations in various areas:

Meteoritics. A. Mesosiderites formed at the core-mantle interface of a differentiated parent body, created by crustal foundering as we have previously proposed (1). B. Parent bodies for metal-rich meteorites were three times smaller than previously calculated; otherwise, collisions would be incapable of baring their cores. Deep insulating megaregoliths permit slow cooling of the cores.

Dynamics. A. Meteorites are derived mainly by cratering rather than by catastrophic disruption of parent bodies (the fragments created in frequent disruption travel too slowly to reach resonances or else the chunks are too big and impact too infrequently to contribute to the record of falls). B. For similar reasons, meteorites are derived mostly from the main belt, not from Apollo asteroids. C. Achondrites and ordinary chondrites are derived preferentially from rather large asteroids, including one or two that are not particularly near a major resonance.

Asteroids. A. Most moderate-sized asteroids are highly pulverized by repeated impacts, and smaller asteroids (including Apollos, if derived from the main belt) are structurally weak fragments of larger ones. B. S-type asteroids are interpreted to be mostly of ordinary chondrite-like compositions (4), not stony-irons. The largest metallic asteroids are ≤50 km diameter in our view, so the larger E-types are more likely akin to enstatite chondrites. C. Small main-belt asteroids less massive that 10^{13} g are much less abundant than implied by extrapolation from observable sizes; otherwise, our weak Apollos would be destroyed too rapidly and far too many rocky parent bodies (e.g., for ordinary-chondrite-like meteorites) would be sampled.

Finally, we note that while it is not necessary for us to invoke comets as parent bodies for meteorites, too little is known about comets to exclude them. It does appear, however, that we can reconcile the existing sample of meteorites with a main-belt asteroid origin alone.