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Fluid Mechanics Prize-Otto Laporte Lecture: The Art of Mixing with an Admixture of Art: Fluids, Solids, and Visual Imagination

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Arguably, fluid dynamics is intimately linked with visual imagination more than any other branch of physical sciences. A particular example is mixing. Fluid mixing, and under more limited circumstances, granular mixing, can be placed in the framework of dynamical systems and a geometric viewpoint. On the fluid mixing side, the physical connection can be traced back to the stretching and folding of fluid elements and possibility of representation motions in terms of transformations. This opens a wealth of possibilities — the mathematical machinery of dynamical systems on the theory side, and the possibility of inventing devices on the practical side. There are notable differences as well: granular materials un-mix or segregate, often spectacularly so, and some aspects of segregation can also be incorporated in the mathematical framework. A technical review will highlight key points in both areas – experiments, applications, and the many branches that have taken root since the mid-1980s. However, much of this could have taken place sooner. The basic mechanisms and key experimental results in both areas were identified early: the stretching and folding mechanism of mixing was pointed out by Osborne Reynolds in 1893-1895, and a key segregation mechanism of granular mixtures was noted by Yositisi Oyama in 1939. In what may appear surprising on a first viewing, these leads were not followed. Ideas, in order to be embraced, need to fit with the canonical knowledge of the times.