Science education researchers now broadly agree about the fundamental role of the literacies of science in learning in elementary and secondary school (Gee, 2004; Lemke, 1998, 2003; Moje, 2007; Norris & Phillips, 2003; Yore, 2004). These literacies include all the signifying language practices of science discourse, including verbal, visual, and mathematical languages, as well as understanding the purposes and rationale for these literacies in representing scientific thinking and practices. For example, verbal language refers not just to technical science vocabulary and knowledge of functional features of particular science text types but also to verbal reasoning capacities evident in scientific explanations (Osborne, Erduran, & Simon, 2004). There is now broad consensus that students need to learn what Moje has characterized aptly as “disciplinary literacy” (p. 1). In the case of science, this means that students need to (a) learn how, why, and when they should interpret and construct models, graphs, tables, and diagrams and then (b) integrate these representations with the written language of science as part of the broader process of becoming scientifically literate.

Researchers in this field are united in seeking to characterize and explain current or possible future effective classroom practices that promote, or could promote, this disciplinary learning. However, as with all key curricular areas in school, researchers are now also more aware of (a) the marked diversity of learners’ needs, cultural resources, and representational capacities; (b) the impact of new technologies on how science is conducted and represented in the science community, and possible or desirable parallel teaching and learning tasks in school; and (c) the complex challenges entailed in students learning the meaning-making and knowledge-production practices of this subject. In the science education research community, this has led to a fitting diversity of research orientations and foci for study.

Recent research has been guided by different theories of how this learning might be characterized and promoted, drawing variously on constructivist, semiotic,
genist, conceptual change, systemic linguistics, sociocultural, postmodern, and cognitive science theories of meaning-making. Researchers have also used multiple interpretive frameworks to guide their data collection and analyses and have focused on different areas, such as the needs of particular student cohorts, the role of teacher-provided and student-constructed representations, the effectiveness of different student task types and varied technological resources, teacher and student roles, videotaping of classroom interactions with artifacts, and comparative studies of student academic performance following contrasting teaching programs. There has also been recognition of the need for a mix of quantitative and qualitative methods in much of this research so as to measure change and to identify (and explain) participant perceptions and attitudes.

Given the rich diversity and emergent nature of this research, this chapter provides only a broad outline of major developments in this field, noting areas of consensus about effective classroom practices, complementary possibilities across different research methods and foci, and future potential research areas. I focus mainly on student text production in science learning, while acknowledging that this learning entails both constructing and interpreting texts and that many researchers are working predominantly in the area of designing effective texts for students to view, manipulate, and interpret (Ainsworth, 2006; Schnitz & Bannert, 2003). There is general agreement that interpretation of texts, including manipulation of multimodal texts, needs to be part of future research on effective pedagogies for science learning. As noted by Alvermann (2004), Lemke (2004), and others, science findings and explanations are now represented in videos, CD-ROMs, hypertext, and hypermedia as well as traditional print materials; thus, student interpretation and construction of these different text types pose a range of new literacy learning challenges for teachers and students beyond traditional conceptions of reading and writing in science. However, in order to achieve some useful specificity of focus in this chapter, I will consider mainly research on effective pedagogical approaches to student text production.

To frame discussion about the kinds of research undertaken in this area, I briefly review the assumptions and implications of the current mandated version of research excellence, the Gold Standard (Boruch & Mosteller, 2002), noting how this standard does not align easily with the current state of research on learning the literacies of science.

### 8.1 The Gold Standard

The US Department of Education’s (US ED, 2003) assertion that educational research should be strongly evidence-based and use large randomized controlled trials (RCTs) with intervention and control groups could seem on face value to be appropriate for establishing a Gold Standard for learning the literacies of science. Similarly, the What Works Clearinghouse’s (US Institute of Education Sciences, n.d.) additional guidelines for Gold Standard educational research could seem