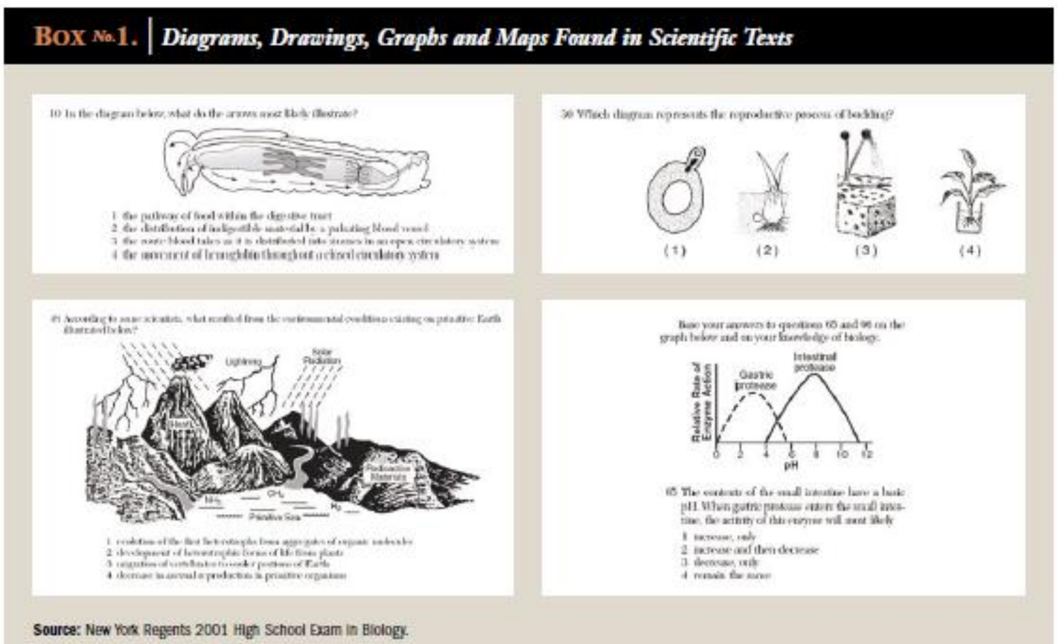
Reading in Science

Scientific texts pose specialized challenges to inexperienced and struggling readers. For example, scientific research reports include abstracts, section headings, figures, tables, diagrams, maps, drawings, photographs, reference lists and endnotes. Science textbooks usually include similar elements. Each of these elements serves as a signal as to the function of a given stretch of text and can be used by skilled readers to make predictions about what to look for as they read, but consider the situation of an adolescent reader confronted for the first time by such texts and trying to make sense of them using the basic decoding tools acquired in "learning to read."

Comprehension of scientific texts also often requires mathematical literacy, or an ability to understand what mathematical tables and figures convey. It is not uncommon for such figures and tables to invite multiple points of view or to open up questions that are not posed directly in the text (Lemke, 1988). Many scientific texts also require visual literacy, using diagrams, drawings, photographs and maps to convey meanings. Box 1 illustrates diagrams, drawings and maps routinely found in scientific texts. These examples are taken from 2001 released items on the New York Regents High School Exam in Biology.



Science texts pose several other important challenges: the use of scientific registers in terms of technical vocabulary and syntax. A register is a way of using language that is specific to particular situations, such as the technical way that lawyers speak in court. For example, scientific texts may define complex technical terms through the use of embedded clauses (i.e. "an invisible gas called water vapor") and nominal apposition (i.e. "animals that eat plants, herbivores, may be found …") (Wignell, 1998, pp. 299–300). Learning such terminology and syntax are important and sometimes difficult challenges of reading to learn in science.

The technical vocabulary of science often has Latin or Greek roots: *cosm* (as in cosmos), *hypo* (as in hypoacidic or hypoallergenic) or *derm* (as in dermatology, dermatitis, dermatoid). Sometimes words will have one meaning in everyday discourse and different and highly specialized meanings in science. Other times, scientific terms will have specialized modifiers of words that we use in ordinary discourse, as in saturated fat or dark matter (White, 1998). Or scientific terms may use common terms in specialized ways with specialized modifiers, as in *catabolic pathway*, or both terms may be specialized, as in *lipoprotein cholesterol* (White, 1998).

Scientific registers also include syntactic forms that can be difficult for inexperienced and struggling readers. Categories and taxonomies represent conceptual relationships that are captured in single words or noun phrases. Russian sociocultural psychologist Lev Vygotsky argued that the classification systems of the sciences represent abstract ways of thinking that are not typically captured in everyday thinking. For example, domesticated dogs that we refer to as canines belong to the kingdom of *animalia*, the phylum of *chordata*, the class of *mammalia*, the order of *carnivora*, and the family of *canidae*. Each of these taxonomic categories in biology represents constructs that capture form/function relationships regarding physical characteristics, behavioral patterns, and positions in evolutionary history within and across animal species. Dogs and humans are related because they are both mammals (i.e. the class of mammalia). They are both mammals because the females of both species have mammalian glands that are capable of producing nourishment for newborns of the species. This form of taxonomic reasoning is pervasive in academic domains, particularly in the sciences, and it requires abstract reasoning because one cannot pick up and hold mammalia or carnivora in the way one can pick up a chair. Thus reading science texts that use such taxonomic terminology requires understanding the multiple and nested relationships entailed in such terms. There may be many relationships to be inferred by the use of such terminology that are not explicitly stated in the texts.

Scientific registers also include syntactic forms that can be difficult for inexperienced and struggling readers (Wignell, 1998). The demands of comprehending scientific text are discipline specific and are best learned by supporting students in learning how to read a wide range of scientific genres. Besides text structures emphasizing cause and effect, sequencing and extended definitions, as well as the use of scientific registers, evaluating scientific arguments requires additional skill sets for readers. These additional skill sets are based on knowledge of scientific reasoning, as expressed in this statement from the Association for the Advancement of Science:

> Over the course of human history, people have developed many interconnected and validated ideas about the physical, biological, psychological, and social worlds. Those ideas have enabled successive generations to achieve an increasingly comprehensive and reliable understanding of the human species and its environment. The means used to develop these ideas are particular ways of observing, thinking, experimenting, and validating. These ways represent a fundamental aspect of the nature of science and reflect how science tends to differ from other modes of knowing. (American Association for the Advancement of Science, 1993).

The benchmarks for scientific literacy by the Association for the Advancement of Science illustrate the quality and scope of knowledge required for scientific literacy (American Association for the Advancement of Science, 1993).

BOX №2. | *Benchmarks for 12th Grade Scientific Literacy*

By the end of the 12th grade, students should know that:

- Investigations are conducted for different reasons, including exploring new phenomena, to check on previous results, to test how well a theory predicts, and to compare different theories.
- Hypotheses are widely used in science for choosing what data to pay attention to and what additional data to seek, and for guiding the interpretation of the data (both new and previously available).
- Sometimes, scientists can control conditions in order to obtain evidence. When that is not possible for practical or ethical reasons, they try to observe as wide a range of natural occurrences as possible to be able to discern patterns.
- There are different traditions in science about what is investigated and how, but they all have in common certain basic beliefs about the value of evidence, logic, and good arguments. And there is agreement that progress in all fields of science depends on intelligence, hard work, imagination, and even chance.
- Scientists in any one research group tend to see things alike, so even groups of scientists may have trouble being entirely objective about their methods and findings. For that reason, scientific teams are expected to seek out the possible sources of bias in the design of their investigations and in their data analysis. Checking each other's results and explanations helps, but that is no guarantee against bias.
- In the short run, new ideas that do not mesh well with mainstream ideas in science often encounter vigorous criticism. In the long run, theories are judged by how they fit with other theories, the range of observations they explain, how well they explain observations, and how effective they are in predicting new findings.
- New ideas in science are limited by the context in which they are conceived; are often rejected by the scientific establishment; sometimes spring from unexpected findings and usually grow slowly, through contributions from many investigators.

Source: American Association for the Advancement of Science (1993).

These 12th grade benchmarks for scientific literacy form the basis for the kinds of discipline specific questions that readers need to ask in evaluating reports of scientific findings, be they historical or current. Such questions include the following:

1. What are the functions of the investigation— to explore, check previous results, test the explanatory power of a theory? The functions of the investigation will influence how the reader evaluates the evidence presented.
2. What data has been collected and how has it been analyzed? Is the data appropriate to the questions and conclusions reached? In a high school science classroom, we should expect students to be able to evaluate the goodness of fit of data, even if we don't expect the general public to be able to critique scientific reports.
3. What are the tradeoffs of the research design, weighing what we can learn from experiments with controlled conditions versus what we can learn from naturalistic or direct observations? While we cannot make naturalistic observations of evolution in situ because the time scales of observable change are so huge, we can make direct observations of fossil records.
4. What are the logical links between data, findings, previous related research and widely accepted theory?
5. What are potential sources of bias that may influence the findings and recommendations?

We can think of these questions as indices of the open and inquiring habits of mind of the scientifically literate adult. Our point is that such lifelong habits are instilled in the general public through the unique opportunity of learning science in school, and specifically in learning to read scientific texts.

References cited in excerpt

Lemke, J. (1998). Multiplying meaning: Visual and verbal semiotics in scientific text. In J. R. Martin & R. Veel (Eds.), Reading science: Critical and functional perspectives on discourse of science (pp. 87-113). NY: Routledge.

White, P. R. R. (1998). Extended reality, proto-nouns and the vernacular: Distinguishing the technological from the scientific. In J. R. Martin & R. Veel (Eds.), Reading science: Critical and functional perspectives on discourse of science (pp. 266-296). NY: Routledge.

Wignell, P. (1998). Technicality and abstraction in social science. In J. R. Martin & R. Veel (Eds.), Reading science: Critical and functional perspectives on discourse of science (pp. 297-326). NY: Routledge.

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