

Science without Literacy: A Ship without a Sail?

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LANGUAGE
AND LITERACY IN
SCIENCE EDUCATION



JERRY WELLINGTON
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The Basic Argument

- Being scientifically literate means more than knowing the substantive content; reading is a constructive process
- Primary access to science is through texts
- Teaching how to read in science is teaching science

Science exists because scientists are writers are speakers. We know this, if only intuitively, from the very moment we embark upon a career in biology, physics or geology. As a shared form of knowledge, scientific understanding is inseparable from the written and spoken word. There are no boundaries, no walls between the doing of science and the communication of it; communicating is the doing of science. If data falls in the forest and no one hears it... Research that never sees the dark of print remains either hidden or virtual or nonexistent. Publication and public speaking are how scientific work gains a presence, a shared reality in the world.

Montgomery, S. L. (2003). *The Chicago Guide to Communicating Science*. Chicago: University of Chicago Press.

Tenopir, C., & King, D. W. (2004). Communication patterns of engineers and scientist. Hoboken, New York: Wiley.

- 25% of their time reading
- 58% with speaking and writing
- Reflection of the value of the activity

Why is the sky blue?

Is the Universe Infinite?

Why do species evolve?

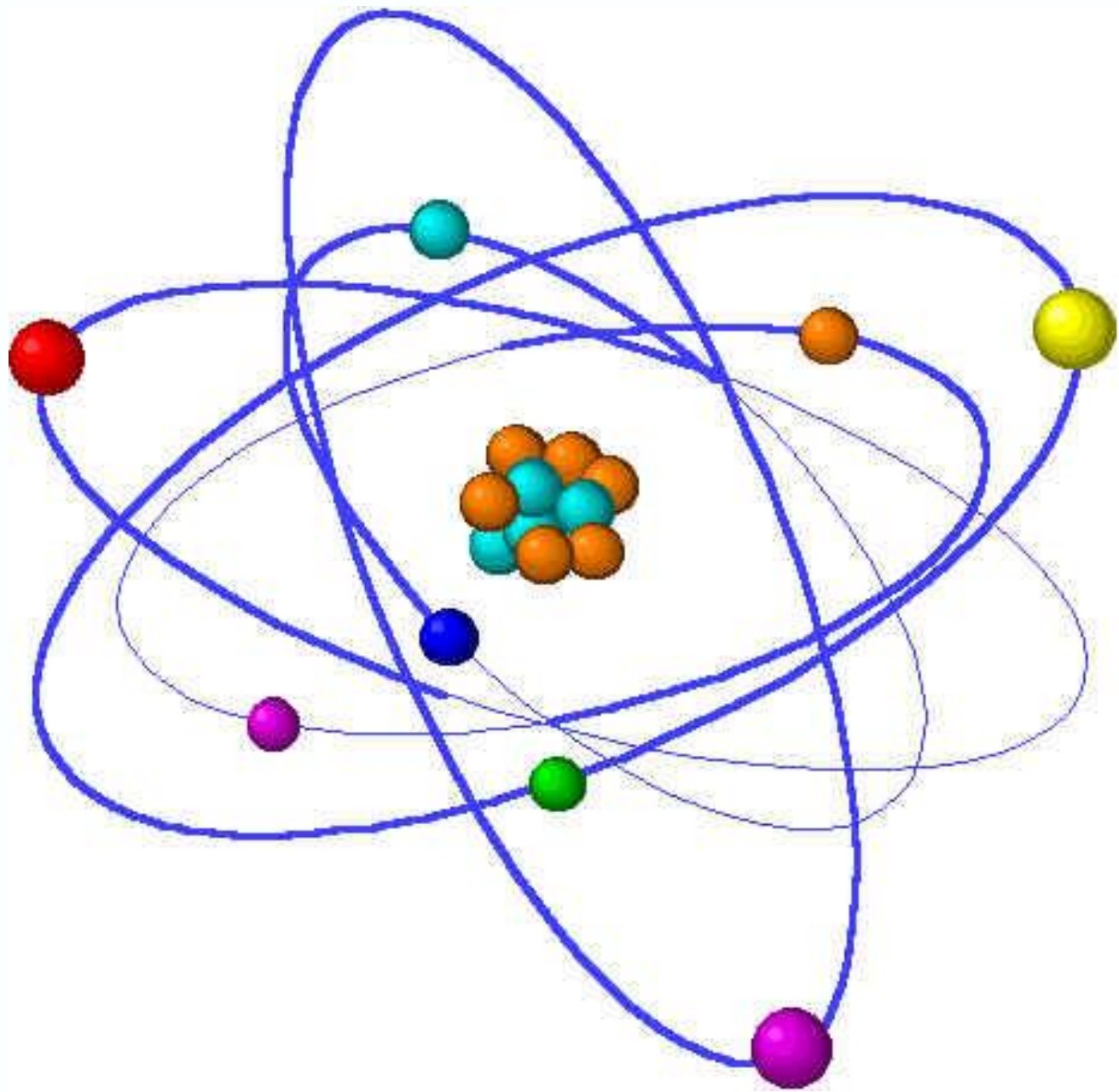
What is the difference between mitosis
and meiosis?

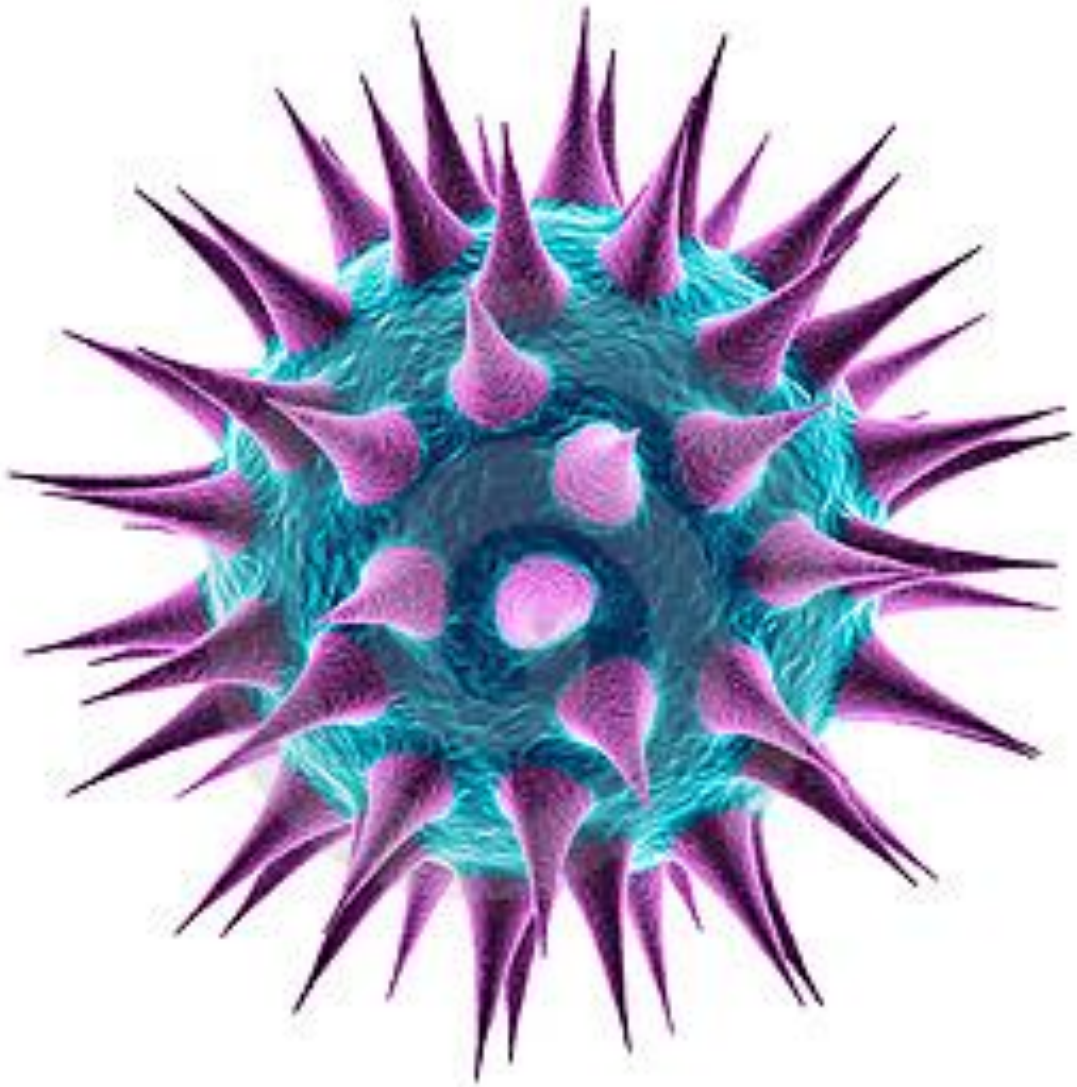
Why do some things float
and others sink?



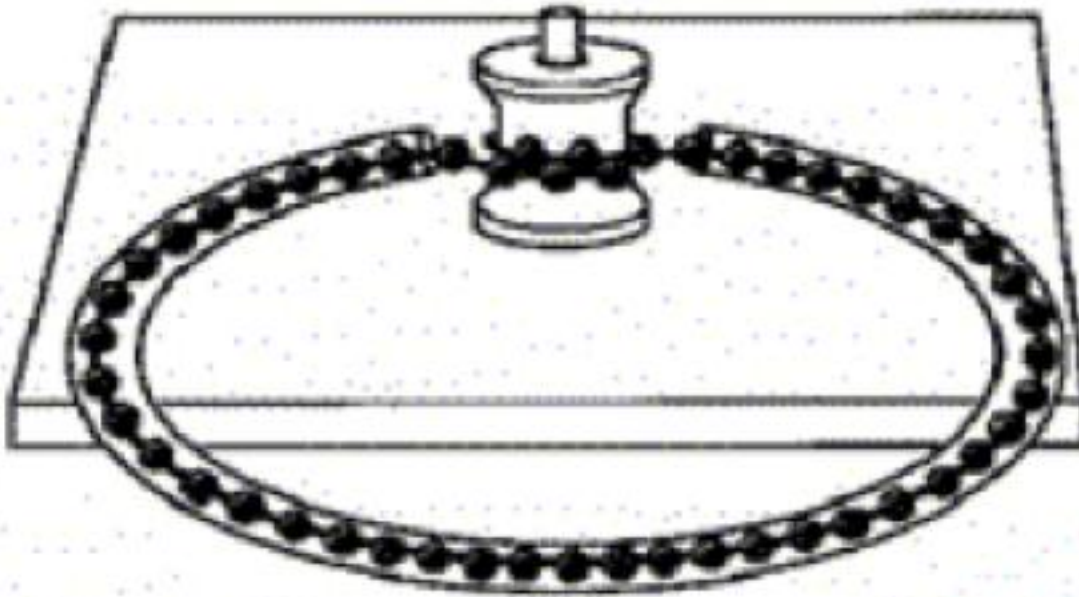
Constructing Entities

- How would you describe to a pupil the following?
 - † An Onion Cell
 - † An atom
 - † A microbe
 - † What an electric current is?

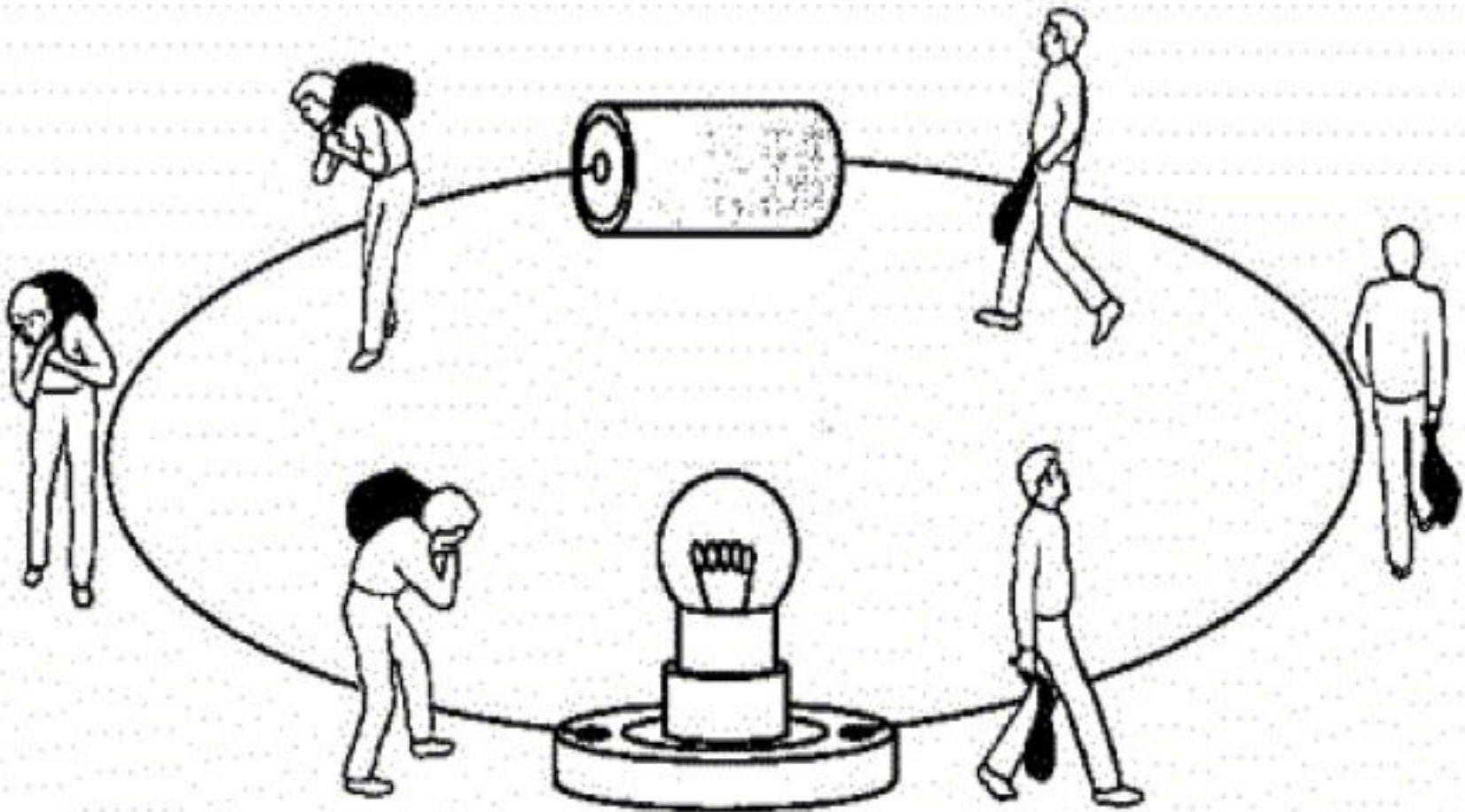




Models of Electric Circuit: The Bicycle Chain



Models of Electric Circuits: Jewels and Couriers



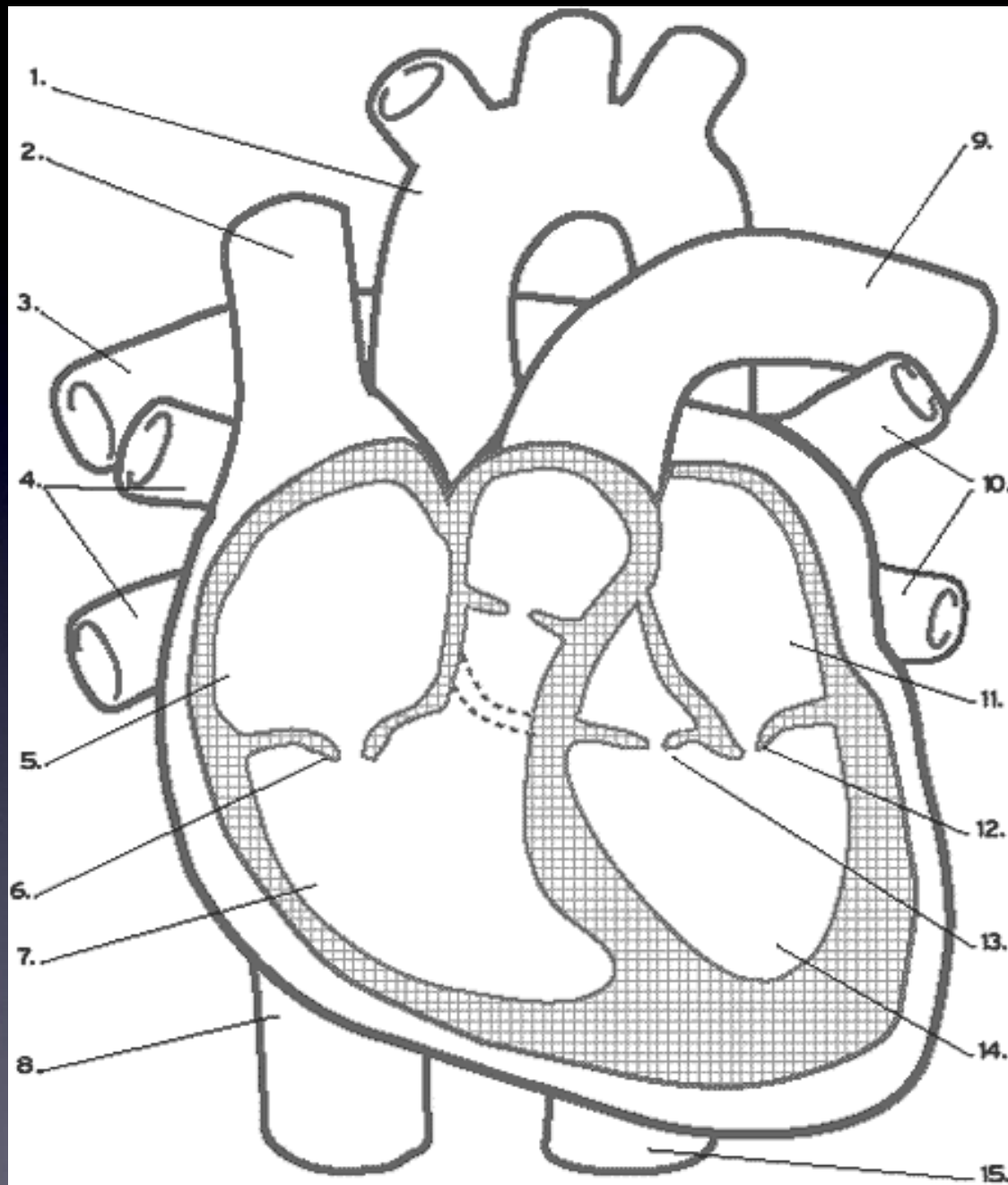
Words

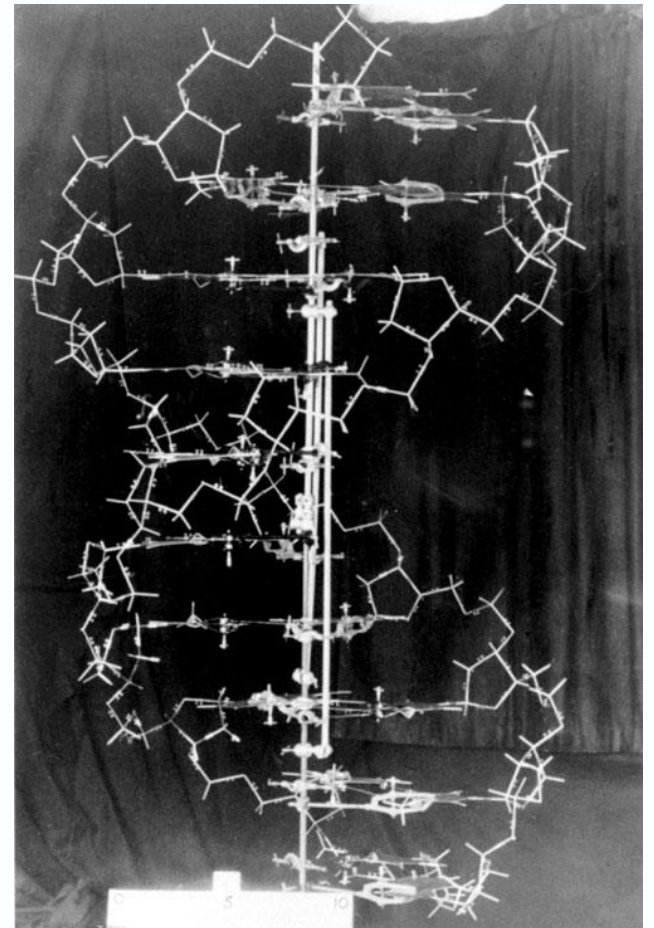
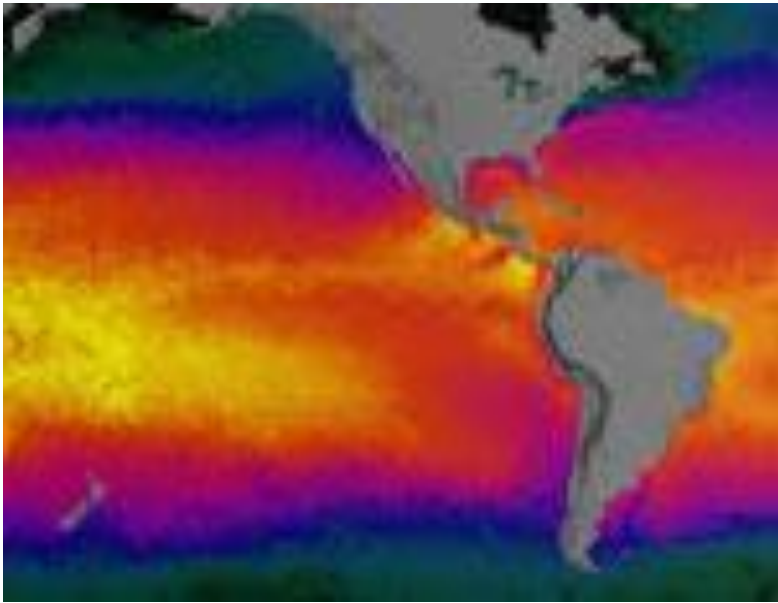
- Photosynthesis
- Homeostasis
- Mitosis
- Meiosis
- Exothermic
- Ionisation

Number of Words

- Studies of high school physics texts
- 2000 technical terms
- 8 new words a lesson
- More than in foreign language lessons

Merzyn, G. (1987). The language of school science. *International Journal of Science Education*, 9(4), 483-489.





Original DNA demonstration model (scale gives distance in Angstroms)

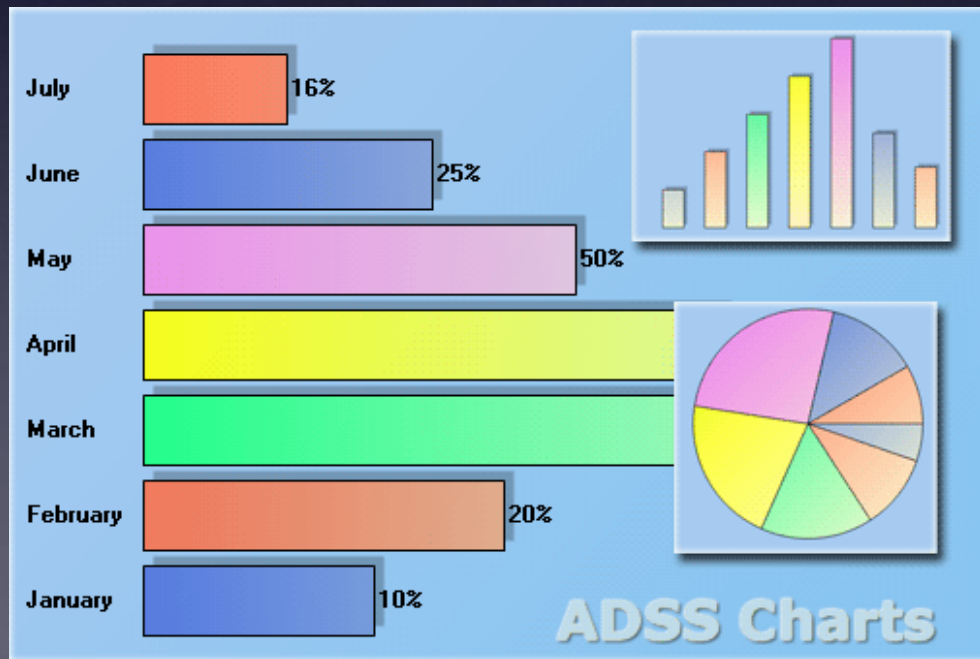
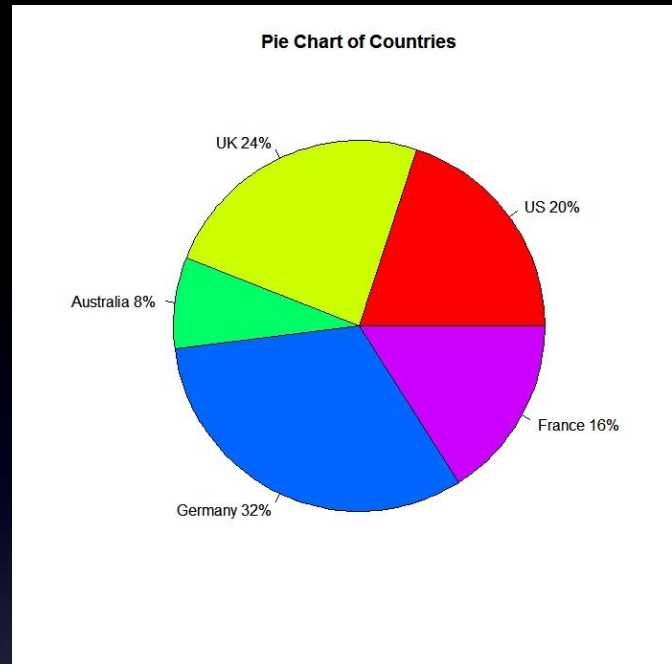
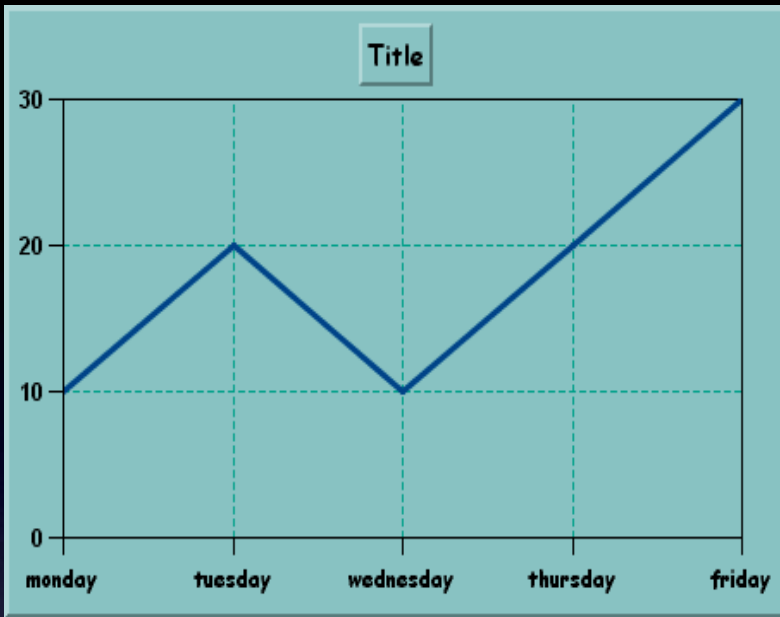
Cold Spring Harbor Laboratory Archives

$$\nabla \cdot \mathbf{E} = 0$$

$$\nabla \cdot \mathbf{B} = 0$$

$$\nabla \times \mathbf{E} = -\frac{\partial \mathbf{B}}{\partial t}$$

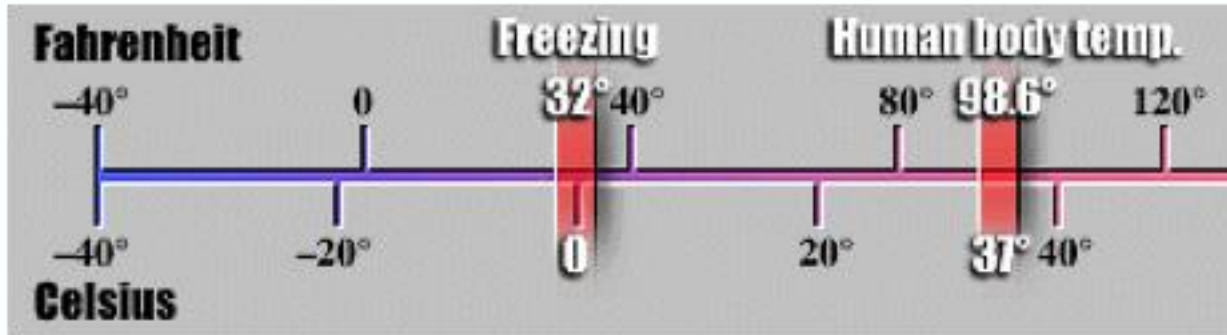
$$\nabla \times \mathbf{B} = \mu_0 \epsilon_0 \frac{\partial \mathbf{E}}{\partial t}$$



Problem 1: The languageS of science

- Science uses
 - Words (often in an unfamiliar and special way)
 - Diagrams
 - Charts and graphs
 - Symbols
 - Mathematics
- Multi-semiotic mode of communication.

The chart below will help you quickly make rough conversions between the Fahrenheit and Celsius temperature scales. To make more exact conversions, use the formulas below the chart.



In the formulas below, / means to divide, * means to multiply, - means subtract, + means to add and = is equal. Tc = temperature in degrees Celsius, Tf = temperature in degrees Fahrenheit

To convert a Fahrenheit temperature into Celsius:

$$T_c = (5/9) * (T_f - 32)$$

For example, to convert a Fahrenheit temperature of 98.6°F into degrees Celsius, first subtract 32 from the Fahrenheit temperature to get 66.6. Then you multiply 66.6 by five-ninths to get 37°C.

To convert a Celsius temperature into degrees Fahrenheit:

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The Progressive Nature of Scientific Language

- Scientific Discourse is Cumulative
- The reader of a scientific paper is entering a conversation that has been going on for over 2000 years.
- Each step in science builds on the last. Hence, science progresses in a fundamental sense which art does not - so its discourse inescapably deviates increasingly from that of everyday life, except inasmuch as it feeds back into and changes everyday discourse. Professional science writing, with or without equations, is thus inescapably difficult.'

Understanding Language in the context of its use

Which sentence uses the word maximum correctly?

- a. The lazy boy always made the maximum effort to improve his work.
- b. The team won the maximum number of points and were relegated.
- c. He wanted to sell his car and make the maximum profit.
- d. By dividing the total of all the marks by the number of pupils who sat the test, the teacher was able to work out the maximum mark.

Understanding words in their Context

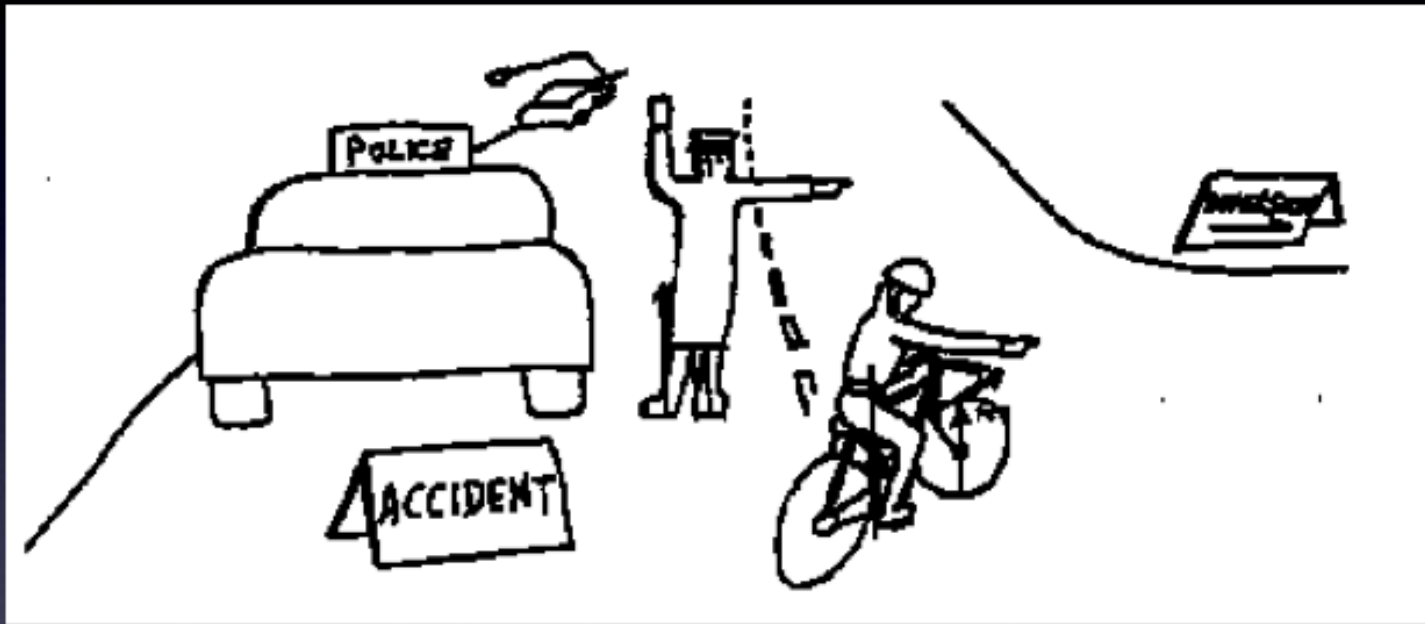
Word	Grade			% Correct
	7	10	12	Mean
Accumulate	21	32	72	44
Devise	36	44	61	49
Random	7	21	50	30
Theory	21	49	67	49

Problem 2: Polysemy

- Does 'Electricity' mean?
 - ❖ Electrical power
 - ❖ Electrical current
 - ❖ Electrical Voltage
 - ❖ Electrical Charge

- The demand for electricity was low
- The electricity nearly killed him
- Today's society need more electric cars

The Traffic Diversion



1. A force from the police officer causes the cyclist to turn right.
2. A frictional force acts on the bicycle
3. Forces of reaction from the road act on the police officer and the cycle

Problem 3

Alternatively

Therefore

Consequently

However

Logical Connectives

Problem 4: Lexical Density

Common English

- We never did anything very much about science in our school
- My mother was madly in love with my father

Scientific English

- The atomic nucleus absorbs and emits energy in quanta or discrete units.
- These glands produce the enzyme maltase which breaks maltose down into glucose, thereby finishing off the digestion of starch

The Simple View of Reading

We assumed that the atomic energy levels were infinitely sharp whereas we know from experiment that the observed emission and absorption lines have a finite width. There are many interactions which may broaden an atomic line, but the most fundamental one is the reaction of the radiation field on the atom. That is, when an atom decays spontaneously from an excited state radiatively, it emits a quantum of energy into the radiation field. This radiation may be reabsorbed by the atom. The reaction of the field on the atom gives the atom a linewidth and causes the original level to be shifted. This is the source of the natural linewidth and the Lamb shift.

1. According to the passage, observed emission lines are:
 - A. infinitely sharp
 - B. of different widths,
 - C. of finite width
 - D. the same width as absorption lines.

The Simple View of Reading

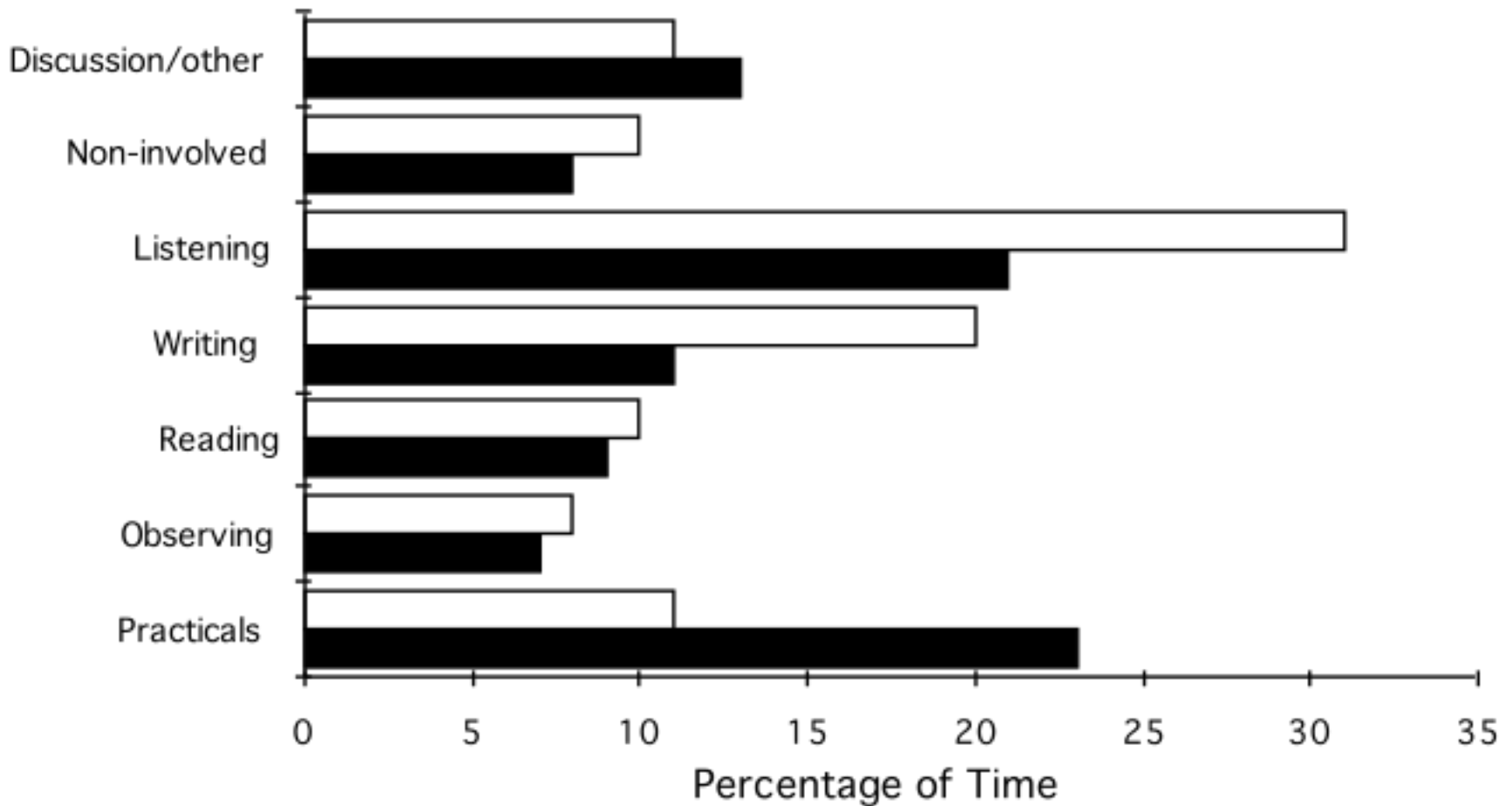
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2. It can be inferred that when an atom decays it may:
 - A. return only to a state more excited than the original one
 - B. not return to its original excited state
 - C. return to its original excited state
 - D. return to a state less excited than the original one.

The Simple View of Reading

3. Do you have the faintest clue what this passage is about?

Types of Activities



Types of Activity



The Importance of Language

‘The one single change in science education that could do more than any other to improve student’s ability to use the language of science is to give them more actual practice using it.’

Lemke, J. L. (1990). *Talking Science: Language, Learning and Values*. Norwood, New Jersey: Ablex Publishing.

Promoting the Use of Language in Science

- Reading Science
- Talking Science
- Writing Science

Reading in Science

- Normal Reading is a RECEPTIVE process

BUT

- Reading in Science is a REFLECTIVE process

Reading Science

- Directed activities related to text (DARTS) are a set of strategies designed to get pupils to
 - ❖ locate important information and reflect on it
 - ❖ to categorise it, and/or
 - ❖ to record it

Directed Activities Related to Texts

Restructuring DARTS	Analysis DARTS
Sequencing CLOZE Diagram Completion	Underlining Tabulating Labelling

Talking Science

- Concept Mapping
- Discussion of Instances
- Reciprocal Reading
- Concept Cartoons

Types of Writing

	Year 7	Year 10
Copying or Dictated Note Taking	46	56
Making Notes from Printed Material	0	19
Essay or reports of Experiments	29	8
Answering Worksheets	25	17

Audiences for Science Writing

	%
Self	0
Trusted Adult	0
Pupil-teacher dialogue	7
Teacher examiner	87
Peer group	0
Public	0
Miscellaneous	6

Writing in Science

Writing provides:—

‘a mode for argument, conjecture, and challenge. In writing, learners will articulate reasons for supporting particular claims and attempt to persuade or convince their audience; they will express doubts, ask questions, relate alternate views, and point out what is not known.’

Rowell, P. (1998). The Promises and Practices of Writing. *Studies in Science Education*, 30, 19-56.

Writing Frames

These words may help you in your writing

- This shows that
- Another piece of evidence is
- A further point is
- I would also argue that
- You can see that
- This means
- Therefore

• Conclusions

- What do my results show?
- How confident can we be of that conclusion?
- What could we do to improve the final result?

Changing the Audience

- a. For a friend who missed the lesson in school
- b. For their mother to explain what they did in school today
- c. As a poem
- d. Write an article for a school magazine
- e. As a set of instructions for somebody else to do the experiment
- f. As a limerick
- j. As a report in the Times
- k. As an entry in their own diary
- l. For a younger pupil to explain why science is fascinating
- n. As an article for a popular magazine
- p. As a time traveller from the 16th Century



186282 299792 **air** amount argon **atmosphere** called common contain
 depend depending **different** **dust** earth electric **electromagnetic**
energy example **field** **frequency** **gas** **gases** higher kind km/sec
light made material **ocean** part **particle** plus pollution radiate radiation **range** sharp
small **soot** **space** spectrum **thing** **travel** vapor very **vibrating** **water**
wave **wavelength** **Waves**

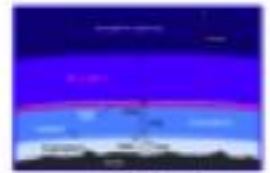
Sort: [Common to Rare](#) | [Rare to Common](#) | [A to Z](#) | [Z to A](#) | [Squish Cloud](#) | [Unsquish Cloud](#) |

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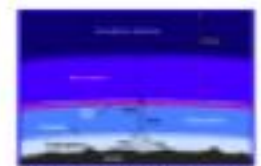
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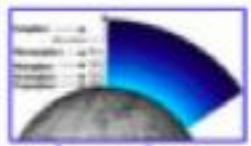
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However, the atmo
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www.kidscan.com



Layers of the Atmo
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rcantib.nhuc.utk.edu



Atmosphere
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www.thentnnehole



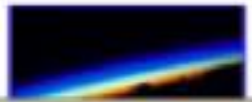
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Visual Thesaurus for 'atmosphere':

- aura
- atmospheric state
- gas
- ambience
- ambiance
- air
- atmosphere
- standard atmosphere
- standard pressure

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A Cautionary Note?

Technical language has evolved in order to classify, decompose and explain. The major scientific genres—report, explanation and experiment—have evolved to structure texts which document a scientist's world view. The functionality of these genres and the technicality they contain cannot be avoided; it has to be dealt with. To deal with it, teachers need an understanding of the structure of the genres and the grammar of technicalityWays must be devised to provide access to this technology. And the answer must not be watering the technology down.'

Halliday, M. A. K., & Martin, J. R. (1993). *Writing Science: Literacy and Discursive Power*. London: Falmer Press.

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