

## Chapter 2

# The Evolution of a Language of Science

From some time in the first year of life, a human infant is communicating with those around him, and his acts of meaning follow two broad functional motifs, one the ‘ideational’ (language as a way of thinking) and the other the ‘interpersonal’ (language as a way of acting). These two motifs, or metafunctions of language, constitute the fundamental semiotic resources with which we gain some mastery of our environment; they are in fact the two aspects that are involved in any kind of meaningful activity. In order to achieve anything, we have both to **understand** some domain and to **act** in some way upon it. It is not surprising therefore that all human languages, both infant protolanguage and every adult language spoken anywhere on this planet, are organized around these two complementary functions. In adult language, they lie at the foundations of grammar.

Now, the **infant** does not yet have a grammar—there is no grammar in protolanguage, only meanings and their expressions (in sound or gesture). But these two functions are clearly present, and clearly distinct, from the start, and they seem to constitute the principal strategy that children use for making the leap from their protolanguage into the mother tongue. Children take this step in the space of just a few months. With the human race, it probably took two million years. In my opinion—and I stress that it is only an opinion—it is likely that our babies are in fact recapitulating the linguistic evolution of the human species (just as in embryo they recapitulate biological evolution), but we shall never know. All languages spoken in the world today represent a fully evolved state—there is no such thing as a simple or primitive language, and when children start to speak in their mother tongue, they simply leap over those hundreds of thousands or millions of years that our languages took to evolve to their present state.

So we cannot watch the system of language evolving; we have to take it as it is, ready made. We can however track some of its very **recent** evolution, and today, I want to follow the historical trail in one particular manifestation, that of the evolution, in English, of modern scientific discourse. And while such an excursion into history might seem at first sight to be just a pleasant diversion, something of an academic luxury, I think it is rather more than that: I think this historical perspective can give us some additional insight into the kind of language that our children have to come to terms with when they go through their years of school.

In the previous lecture, I referred to the distinction between commonsense knowledge and educational knowledge, a distinction that is drawn by sociologists, in the sociology of knowledge. I used the sociologists' labels, but I emphasized that the distinction, as I was drawing it, is a linguistic one. It would be nice if we could say there was no difference, between the everyday, natural, typically spoken language of the home and neighbourhood and the technical, somewhat contrived, typically written language of educational disciplines, but in fact there **is** a difference, and it is one that we have to recognize and interpret. Educational discourse is something that children have to learn, and with which they may have problems. Such problems will be difficult to overcome if their teachers do not understand the nature of the linguistic demands that are being made on them. Furthermore, many of these problems arise just as much in monolingual education systems as they do in multilingual communities. So it is particularly important to be able to recognize what are the linguistic demands that are imposed simply by the process of becoming educated—of having to learn the discourse of mathematics, of science, of history, of economics and so on. We can then ask how such problems become further complicated if more than one language is involved.

So the purpose of today's talk is to try to identify the essential nature of scientific discourse, taking this as **one** of the registers of language in education: one that is obviously important because of the central place that science **has** in education, but also because it exhibits in a rather clear and sometimes extreme fashion the features that are found in the language of educational disciplines in general. At first, I had intended just to examine scientific language as we find it today, but then in order to explain its particular features, and to suggest that they are not merely arbitrary conventions, I thought it might be more effective to show something of how they had evolved. This would be another application of the historical approach: another beginning, so to speak, except that we cannot in this space of time go right back to the earliest origins.

Today, then, we shall explore some aspects of the language of science as it has been evolving in English since the fourteenth century. I shall examine passages written by four masters in the field: Geoffrey Chaucer, Isaac Newton, Joseph Priestley and James Clark Maxwell. We can identify these passages by their time intervals: each of the works I have chosen was written fairly late in a particular century:

Chaucer:	A Treatise on the Astrolabe	1391
Newton:	Opticks, or, a treatise of the reflections, refractions, inflections and colours of light	1675–87
Priestley:	The History and Present State of Electricity, with original experiments	1767
Maxwell:	An Elementary Treatise on Electricity	1874

So, roughly the data from one hundred, two hundred, three hundred and six hundred years ago. We will begin with Chaucer—who will no doubt be more familiar to many among you as the author of the *Canterbury Tales*, but who was also a not inconsiderable mathematician and astronomer.

In the year 1391, Geoffrey Chaucer wrote a scientific treatise for his son Lewis. It is known, now, as the *Treatise on the Astrolabe*, and much of it is an account of the workings and use of the astrolabe, which was the principal astronomical instrument at that period. The treatise was in fact written to accompany an astrolabe which Chaucer had given his son as a present. 'Litell Lowis' was then ten years old.

The treatise was written in English. 'I have given you', Chaucer writes:

*an Astrolabe suitable to our horizons, constructed for the latitude of Oxford; and by means of this little treatise I propose to teach you a certain number of principles relating to this instrument. ... I will write the treatise for you*

*<under ful lighte rewles and naked wordes in English>*

*using simple structures and plain words in English; for Latin you know only a little. But let these true principles suffice for you in English as well as do the same principles for the noble Greek clerics when written in Greek, for the Arabians in Arabic, for the Jews in Hebrew and for the Latin peoples in Latin ...*

The treatise was to have been in five parts, the fourth and fifth being designed as 'a theory to describe the movings of the heavenly bodies, with their causes' and 'an introduction based on the writings of our scholars <doctours>, in which you can learn a great part of the general rules of theory in astronomy <the general rewles of theorik in Astrologie>'. Unfortunately, only the first two parts were written, or at least only these have survived.

Chaucer does not claim the treatise to be original; he says 'I am only a crude compiler of the work of the old astronomers <Astrologiens>, and have translated it into my English just for your instruction'. But it does not appear to derive from a single original; it is I think a compilation rather than a direct translation. Be that as it may, the treatise is of interest as an early essay in technical, scientific English.

Here is a short extract from Part I, which is a description of the astrolabe itself, followed by a passage from Part II which teaches little Lewis how to use it.

#### **Text 2.1: Extracts from Chaucer's *Treatise on the Astrolabe***

(I.17)

*The plate under thy riet ['grid'] is descryved ['inscribed'] with 3 principal cercles; of whiche the leste ['smallest'] is cleped ['called'] the cercle of Cancer, by-cause that the heved ['head'], of Cancer turneth evermor consentrik up-on the same cercle. In this heved of Cancer is the grettest declinacioun northward of the sonne. And ther-for is he cleped the Solsticioun of Somer; whiche declinacioun, after Ptholome is 23 degrees and 50 minutes, as wel in Cancer as in Capricorne.*

(II.17)

*Tak the altitude of this sterre whan he is on the est side of the lyne meridional, as ney as thou mayst gesse; and tak an assendent a-non right ['straight ahead'] by som maner sterre fix which that thou knowest; and for-get nat the altitude of the firste sterre, ne thyn assendent. And whan that this is don, espye diligently whan this same firste sterre passeth any-thing the south westward, and hath him a-non right in the same noumbre of altitude on the west side of this lyne meridional as he was caught on the est side; ...*

Let me note at this point just a few features of the language Chaucer uses. (1) There are of course numerous abstract words: conclusion, declaration, altitude, declination, evidence, equation, mediation, utility, proportion, etc.; most of them are nouns. (2) Some of these abstract nouns function as technical terms, e.g. *declination* (=angular distance of heavenly body from celestial equator), *head/heved* (=point where sun enters the zodiacal sign), *climate* (=segment of the surface of the earth by latitude and longitude), and of course *latitude* and *longitude*, *meridian*. (3) There are nominal groups (that is, expansions of nouns) formed with prepositional phrases with *of*: *Solsticioun of Somer*, *the circle of Cancer*, *the spaces of the hours of planets*, *the poles of this world*, *the zenith of the sun and every star*. (4) There are expressions of general principle, e.g. adverbs such as *evermor* (=always), but also expressions of the kind ‘anything that is *a* is also *x*’ (*any two degrees that are the same distance from either of these two hevedes are of the same declination*). (5) In giving instructions, Chaucer uses some action-type verbs (*take the altitude of this star*), and numerous mental processes (*understand well*, *forget not*, *reckon*, *trust well*, *espy*). Otherwise, a frequent type of clause is one having the verb *be*; this may be assigning an attribute to something (*when the sun is near the meridional line*), or else stating an identification (*the latitude of any place in a region is the distance from the zenith to the equinoctial*). (6) There are expressions of cause and condition: *when*, *if*, *because*, *for*, and *therefore*. (Note that one common context for these is explaining a technical term: *the last is called the circle of Cancer because the head/heved of Cancer always turns concentric upon this circle*.) (7) Various devices exist to carry forward the argument step by step, for example non-defining relative clauses (*the names of the stars are written in the margin of the Rete where they are located; of which stars the small point is called the Centre*)—this is actually an instance of a varied set of features whereby a particular entity is introduced into the discourse and then kept track of through a paragraph or more of the text.

These are some of the features of a piece of scientific English as it was beginning to emerge some six hundred years ago. From the modern point of view, it is perhaps technical rather than scientific as we would understand this term today; but we should not I think draw this distinction too sharply. It is clearly already a language for reasoning with, in which statements of general principle can be made and conclusions drawn from real or hypothetical premises. Of course, the **evolution** of this kind of technical discourse in the west took place in ancient (pre-classical and classical) Greek, in classical and medieval Latin; not in English or French or Italian or any of the modern European languages. But it is the subsequent developments we need to be concerned with, leading up to the forms of technical and scientific English that we are typically confronted with today, and for this purpose, it is reasonable to take the scientific English of Chaucer as our point of departure. It is interesting also to compare its linguistic features with those of the primary science textbook I illustrated in the previous lecture (bearing in mind that Chaucer intended it for his 10-year old son whose Latin was not very good yet).

From Chaucer we will move forward 300 years, to Isaac Newton whose ‘Treatise on Opticks’ was written towards the end of the seventeenth century. This period of three hundred years (1400–1700) is usually regarded as critical in Western scientific

thought, encompassing as it did the ‘birth of scientific method’ with Copernicus, Galileo and Newton. Although experimental science was foreshadowed in earlier medieval times, particularly in the work of Roger Bacon, it did not become established until the period of the Renaissance, and Isaac Newton did more than any other single scholar to establish experimental method as the new scientific paradigm. Let us look at some specimens of Newton’s writings. Much of his work was written first in Latin and then translated, but the *Opticks* was composed from the start in English.

**Text 2.2: Extract from Newton’s *Treatise on Opticks* (Experiment 4)**

*In the Sun’s Beam which was propagated into the Room through the hole in the Window-shut, at the distance of some Feet from the hole, I held the Prism in such a Posture, that its Axis might be perpendicular to that Beam. Then I looked through the Prism upon the hole, and turning the Prism to and fro about its Axis, to make the Image of the Hole ascend and descend, when between its two contrary Motions it seemed Stationary, I stopp’d the Prism, that the Refractions of both sides of the refracting Angle might be equal to each other, as in the former Experiment. In this situation of the Prism viewing through it the said Hole, I observed the length of its refracted Image to be many times greater than its breadth, and that the most refracted part thereof appeared violet, the least refracted red, the middle parts blue, green and yellow in order. The same thing happen’d when I removed the Prism out of the Sun’s Light, and looked through it upon the hole shining by the Light of the Clouds beyond it. And yet if the Refraction were done regularly according to one certain Proportion of the Sines of Incidence and Refraction as is vulgarly supposed, the refracted Image ought to have appeared round. So then, by these two Experiments it appears, that in Equal Incidences there is a considerable inequality of Refractions. But whence this inequality arises, whether it be that some of the incident Rays are refracted more, and others less, constantly, or by chance, or that one and the same Ray is by Reflection disturbed, shatter’d, dilated, and as it were split and spread into many diverging Rays, as Grimaldo supposes, does not yet appear by these Experiments, but will appear by those that follow.*

1. First let us look at the kinds of process he is writing about—the actions, events and so on:

- (a) *I held the Prism. I stopped the Prism. I removed the Prism. I held a white Paper*
- (b) *I looked through the Prism upon the hole*

These clauses express actions on objects, and also behaviour. They may be followed by a mental process of cognition or perception, together with a projected observation of fact:

*I observed the length of its refracted image to be many times greater than its breadth.*

We found similar clauses in Chaucer, as instructions, also sometimes followed by a mental process with its projection:

*Take the altitude of this star ... and forget not the altitude ... And when that this is done espye diligently when this same first star passeth anything the southwestward*

But Chaucer’s of course had the imperative mood, Subject ‘you’; Newton’s are declarative, past tense, Subject ‘I’, describing an experiment. Since they are describing an experiment, these clauses sometimes appear in the passive.

*The Sun's Beam was propagated*

*One and the same's Ray is by Refraction disturbed, sheltered, diluted, split and spread*

It is interesting to note that these are *not* the 'suppressed person' passives that modern writers use (and teachers and editors often insist on) to make the discourse seem more objective; they simply describe what happened as a **result** of an experimental step he had taken.

Then in addition to the actions, behaviours and mental processes which are characteristic of Newton's experimental descriptions, we find a large number of attributive descriptive clauses with *be* and similar verbs used to express the results of his observations:

<i>its Axis might be perpendicular to that</i>	<i>is homogeneallheterogeneous</i>
<i>Beam</i>	<i>remain still a middle colour</i>
<i>the refracted image ought to have</i>	<i>grow more and more dilute</i>
<i>appeared round</i>	<i>made the Paper look white</i>
	<i>it appeared of that Colour to</i>
	<i>which it approached nearest</i>

The other type of relational clause, with *be* in its identifying (equative) sense—and, again related verbs like *is composed of*—typically occurs in mathematical contexts:

*The proportion of \_\_ is composed of \_\_ and of \_\_ if \_\_ be to \_\_ as 20 to 31*

2. Now let us look at the **things**—the objects and abstractions. There are of course many technical terms:

### **Text 2.3: Examples of technical terms**

general concepts	<i>light colour ray beam image</i>
apparatus and its use	<i>prism lens focus</i>
geometric and	<i>perpendicular Sine axis</i>
trigonometric terms	
theoretical concepts	<i>spectrum refraction refrangibility incidence reflected</i>
	<i>light/transmitted light heterogeneous rays</i>

As with Chaucer, these often involve nominal group constructions with prepositional phrases following the noun; but now they are getting a little bit longer:

*the common Sine of Incidence out of Rain-water into Air,*

*the excesses of the Sines of Refraction of several sorts of Rays*  
*above their common Sines of Incidence*

*In the Sun's Beam which was propagated into the Room*  
*through the hole in the window-shut*

*(hold the Prism in) such a posture that its Axis might be*  
*perpendicular to that Beam*

What is the function of these phrases and clauses that occur as postmodifiers to the noun?

Given that a common noun, e.g. ‘beam’, is the name of a class of phenomena (objects), all these postmodifying elements—prepositional phrases and defining relative clauses—have an important role in telling us **which** particular member of the class is being referred to:

*The Beam < which Beam? > ... which was propagated into the Room through the hole in the window-shut*

Now, there is nothing unusual about the pattern; it happens in spoken English all the time, and children master it at a very early age. A three year old would have no great difficulty in processing that last example. But there is an additional feature, or syndrome of features, appearing in Newton’s scientific writing, particularly in the mathematical sections, that was much less evident in Chaucer, and which a 3 year old would have rather more trouble with.

3. The complexity displayed in the mathematical sections of Newton’s treatise was typically characterized by a single clause with only three elements, but very long and complex nominal groups, as in the final two paragraphs of the following (Experiment 8):

**Text 2.4: Extract from Newton’s *Treatise on Opticks* (Experiment 8)**

**EXPER. VIII**

*I found moreover that when Light goes out of Air through several contiguous refracting Mediums as through Water and Glass, and thence goes out again into Air, whether the refracting superficies be parallel or inclined to one another, that Light as often as by contrary refractions ‘tis so corrected, that emergeth in lines parallel to those in which it was incident, continues ever after to be white. But if the emergent rays be inclined to the incident, the whiteness of the emerging Light will by degrees in passing on from the place of emergence, become tinged in its edges with Colours. This I tryed by refracting Light with Prisms of Glass placed within a prismatick Vessel of Water. Now those Colours argue a diverging and separation of the heterogeneous rays from one another by means of their unequal refractions, as in what follows will more fully appear. And, on the contrary, the permanent whiteness argues, that in like incidences of the rays there is no such separation of the emerging rays, and by consequence no inequality of their whole refractions. Whence I seem to gather the two following Theorems.*

1. *The Excesses of the sines of refraction of several sorts of rays above their common sine of incidence when the refractions are made out of divers denser mediums immediately into one and the same rarer medium, are to one another in a given Proportion.*
2. *The Proportion of the sine of incidence to the sine of refraction of one and the same sort of rays out of one medium into another, is composed of the Proportion of the sine of incidence to the sine of refraction out of the first medium into any third medium, and of the Proportion of the sine of incidence to the sine of refraction out of that third medium into the second medium.*

Consider another nominal group of a similar kind just with prepositional phrases in it

*a diverging and separation of the heterogeneous Rays from one another*

Here, the nouns that are being modified in this way are ‘diverging’ and ‘separation’. But notice that these nouns are not names of things and objects; they are names of happenings and processes. We could paraphrase this as:

*the heterogeneous Rays diverge and are separated from one another*

The full sentence reads:

*Now those colours argue a diverging and separation of the heterogeneous Rays from one another by means of their unequal Refractions*

and we could reword this whole clause as something like:

*those Colours argue that the heterogeneous Rays diverge and separate from one another by means of their unequal Refractions*

turning ‘diverging’ and ‘separation’ back into verbs and using a *that* clause. Once we have done this, of course, we might go further, and say

*from those Colours we could argue (or infer) that ...*

– after all **we** do the arguing, the Colours do not, and then at the end say

*because they are refracted unequally*

Now, this sounds more like spoken English. Notice what Newton is doing here. He is using nouns to refer to events—or let us say, nouns to refer to ‘processes’, rather, as a more general term than events; not only those that are part of the technical discourse, like *refraction*, but also others of an everyday kind like *diverging* and *separating*.

Here is another example:

*The explosion of Gunpowder arises therefore from the violent action whereby all the Mixture ... is converted into Fume and Vapour*

which again we could reword as

*Gunpowder explodes therefore because all the Mixture is violently converted into Fume and Vapour*

In these examples (and of course others of a similar kind), Isaac Newton is moving towards the nominalized forms of expression, the ‘nouniness’ that we associate with scientific language today. Not very far but in that direction. This does not mean he is using a lot of nouns—there are a lot of nouns in any kind of English, and there were a lot of nouns already in the Chaucer. But while Chaucer’s nouns were mainly either concrete objects or else **technical** abstractions, such as *declination* and *sol-stition*, with Newton we are also finding nouns of a non-technical kind used to express meanings that would more congruently be expressed by verbs:



*a diverging and separation of the Rays: the Rays diverge and separate*

*the explosion of Gunpowder: Gunpowder explodes*

*the improvement of Telescopes: Telescopes are improved*

But there have to be verbs, in English discourse, to carry tense, polarity and the like; so if the processes are expressed as nouns, where do the verbs come in?—The verb in the first example was *argue*: in other words, what Newton is here treating as the event, the ‘process’, is the act of reasoning, or—since it has *Colours* as its actor (*these Colours argue*)—the relationship of ‘proof’ that he is setting up between the results of the experiment and his conclusion. In the second example, the verb is *arise*: the explosion of gunpowder ‘arises from’ the action of the Mixture; so here what is being treated as the process is the relationship of ‘cause’ between the two events. The events themselves have become nouns, while verbs are used just to express the relationship between them.

And this syndrome has become a kind of key signature in modern scientific discourse. What Newton is doing is building a form of metaphor into his language; but it is a grammatical metaphor, rather than a lexical or word metaphor such as we associate with literary discourse. A grammatical metaphor is one by which the things (phenomena) he is talking about are expressed in the grammar in ways which diverge from the way they are interpreted in the grammar of everyday language, where nouns stand for things, events are expressed as verbs, and the relations **between** events by other word forms, mainly conjunctions and prepositions.

4. Finally, we may note Newton’s use of complex multiclausal structures, for example:

*If the Refraction were done regularly according to one certain Proportion of the Sines of Incidence and Refraction as is vulgarly supposed, the refracted image ought to have appeared round.*

Some express the manner in which something is done, for example:

*not only by teaching those things which tend to the perfection of vision, but also by determining mathematically all kinds of Phenomena of Colours which could be produced by refractions.*

Some are *that* clauses, used in reasoning, for example:

*And, on the contrary, the permanent whiteness argues, that in like Incidences of the Rays there is no such separation of the emerging Rays, and by consequence no inequality of their whole Refractions.*

And occasionally as an earnest of his own good faith, see the final section of the extract:

*... and by the successes I met within the Trials, I dare promise, that to him who shall argue truly, and then by all things with good Glasses and sufficient Circumspection, the expected event will not be wanting.*

Now, we will move forward by a century at a time, taking a brief glance next at Joseph Priestley writing on the history and present state of electricity. When I borrowed his book from our library in Sydney, the assistant was puzzled by its title: how can you write a history of electricity? And this illustrates one of the interesting quirks of English scientific language: we tend to give the same name both to a phenomenon and to the study of that phenomenon: thus in linguistics, *grammar* means both grammar (that is, a particular system within a language) and the study of grammar; Chinese 語法 and 語法學 (Grammatology<sup>1</sup> would be a useful term if not already used for something different.) So here, we need a term *electricology* for the study of electrical phenomena; then, a history and present state of *electricology* would be quite acceptable.

**Text 2.5: Extract from Joseph Priestley's *The History and Present State of Electricity, with Original Experiments***

*According to this theory, all the operations of electricity depend upon one fluid sui generis, extremely subtle and elastic, dispersed through the pores of all bodies; by which the particles of it are as strongly attracted, as they are repelled by one another. When the equilibrium of this fluid in any body is not disturbed; that is, when there is in any body neither more nor less of it than its natural share, or than that quantity which it is capable of retaining by its own attraction, it does not discover itself to our senses by any effect. The action of the rubber upon an electric disturbs this equilibrium, occasioning a deficiency of the fluid in one place, and a redundancy of it in another. The equilibrium being forcibly disturbed, the mutual repulsion of the particles of the fluid is necessarily exerted to restore it. ...*

Although there is no word *electricology* in Priestley's text, there are various other derivatives of *electric*: *electricity*, *electrical*, *electrify*, *electrified*, *electrification* and *electrician* all occur, though not exactly in the senses in which we expect them today. (An *electrician* is a researcher in the field, not someone who comes to mend the wiring in your flat.) These show an important development in scientific English: the use of the morphological resources borrowed from Greek and Latin to create an indefinite number of new related words, a potential which as you will easily recognize is widely exploited in scientific English today. These new words, in turn, serve in the formation of innumerable larger structures—groups, phrases and clauses, with the nominal group as the favoured construction: *electric light/fire* (again not in the modern senses!), *electric fluid*, *electrical battery*, *electrical experiment*, *excited electricity*, *communicative electricity*, *medical electricity*, *conductor of electricity*, *positive and negative electricity*—(the term 'electric shock' also belongs to this period: electric shock was frequently tried in medical treatment, for paralytic conditions such as tetanus, and as a curiosity, when large numbers of people joined hands in a human chain, in one case across the river Thames, and an electric shock administered at one end of the chain was transmitted all the way to the people at the other end!)

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<sup>1</sup>I subsequently called the study of grammar "grammatics"—MAKH.

As far as the semantic and grammatical features of the discourse are concerned, we find further developments in the directions already noted in Isaac Newton's writing: notice how the technical terms are used to summarize so as to carry the argument forward step by step:

*... one fluid sui generis, extremely subtle and elastic, dispersed through the pores of all bodies; by which the particles of it are as strongly attracted, as they are repelled by one another.*

- all this now summarized as *this fluid*, in

*the equilibrium of this fluid, in any body*

which in turn is then summarized as *this equilibrium*, in

*this equilibrium being forcibly disturbed;*

and so on. Again as in Newton, but more so, nominalizations increasingly take over all the semantic content, leaving the verbs to express merely the relations **between** the processes in question:

*Is not the **repulsion** owing rather to an **accumulation** of the electric fluid on the surfaces of the two bodies, which accumulation is produced by the **attraction** of the bodies, and the difficulty the fluid finds in entering them?*

Let us first reword this by 'unpacking' the grammatical metaphor:

*Do not [the electric atmospheres] repel each other because electric fluid has accumulated on the surfaces of the two bodies, [which in turn is] because the bodies are attracted and the fluid cannot easily enter them?*

But instead of a verb *repel*, we have a noun *repulsion*; instead of *accumulate*, *accumulation*; instead of *attract*, *attraction*; and instead of the adverb *not easily* (hardly), the noun *difficulty*. The happenings (processes)—actions, events, etc.—have become nouns. So what do the verbs do?—again, they express the relationship between the happenings. Instead of the conjunction *because*, we have the verbs *produce* (is produced by) and *owe* (is owing to), or a verb to express the mental process of having an opinion—*conceive*:

*Some of the patrons of the hypothesis of positive and negative electricity conceive otherwise of the immediate course of this Repulsion*

- everything else again being nominalized. This recalls Newton's use of *argue*. Material processes—where the happenings are coded as verbs—remain only in the description of the experiments.

We have already put forward a partial hypothesis for why this development in the grammar is taking place; let us restate it in more systematic form. (1) The **nouns** (e.g. *fluid*, *equilibrium*, *repulsion*, *accumulation*) have a particular function in the **text**: they restate, in summary fashion, what has gone before so that it can serve as a point of departure for what is coming next (that is why you so often find an anaphoric deictic with them, e.g. *this* as in *this repulsion*, meaning 'what I have just

been talking about’). (2) Secondly, the nouns have a particular function in the **system** of the language: they are **technical terms**, which means that they are part of the theory—not as isolated terms, but in their systematic relationship one to another. *Equilibrium* is a recognized state which can be disturbed, or maintained; *repulsion* is opposed to *attraction*, both being kinds of force; and so on. There can be no theory without configurations of concepts such as these, and they have to have names. So this kind of nominalization is clearly motivated, **both** in the system of the language **and** in the text.

But we need to account not merely for the **nouns** but also for the nominal groups, where again we find long accumulations of prepositional phrases:

*the mutual repulsion of the particles of the fluid*

*some of the patrons of the hypothesis of positive and negative electricity*

*an accumulation of the electric fluid on the surfaces of the two bodies*

*the practicability of firing mines by electrical explosions*

- and so on; as those were already becoming apparent in our earlier texts. Now, why does Priestley write *the mutual repulsion of the particles of the fluid is necessarily exerted* instead of *the particles of the fluid necessarily repel each other*?

To answer this more fully, we need to add a third part to our hypothesis, for which we would need to explore another aspect of English grammar; this is one that is perhaps less familiar than the patterns I have been referring to so far, because it was not treated at all in the linguistic tradition on which our school grammars have always been based. This is the part of grammar that is concerned with **texture**, with how the sentences, clauses and phrases of the text are organized—are packaged, so to speak—so that they fit in with each other and form a discourse that is relevant, coherent and achieves its rhetorical effect. After all, we do not speak, or write, in sequences of unrelated sentences. We produce discourse, in stretches which may be of any length, according to our needs, but which will always bear some meaningful relationship to its environment—in other words, it will make sense in its particular context.

If I am using a simple expression—say a greeting to a friend who has not been well recently—I do not need to worry about how it will fit into the context: I can just say ‘How are you today?’ and the message will be understood. But notice that even here there is quite a lot of possible variation. I can focus on different points.

<i>how <b>are</b> you today?</i>	–	<i>general concern: you don’t <b>look</b> too good</i>
<i>how are you <b>today</b>?</i>	–	<i>I know you weren’t very well yesterday</i>
<i>how are <b>you</b> today?</i>	–	<i>I know your husband hasn’t been well</i>

and all of these would make slightly different messages, with different textures. This sort of variation is possible with any kind of structure that has more than one element in it, e.g. *I’m flying to K.L. today*, where the stress is variably applied as in the following:

*I'm flying to K.L. today*  
*I'm flying to K.L. **today***

and so on. Now: I could also vary the order of the words, and say

***today** I'm flying to K.L.*

and this has now made a considerable difference to the information that you get from my discourse. If I say *I'm flying to K.L. today*, this is telling you about me: it is as if I was answering some hidden question like 'tell me about yourself—what're you up to?' But if I say *today I'm flying to K.L.*, the implied hidden question is a different one: it is more like 'tell me about today—what's going on today?' Consider the difference between *Next morning I got up out of bed with a new purpose* and *With a new purpose I got up out of bed next morning*. This potential for different ordering becomes especially important when one is building up a long and complex argument, a chain of reasoning, a set of definitions or something else of that kind. It is important, in other words, in technical discourse that the information should be packaged in a way that is appropriate to the context.

Now, there are various aspects to this packaging of information, and various grammatical resources are available for the purpose: putting the word groups and the phrases in the appropriate order is only one part of the picture; but it is a highly significant part of it, at least in English—and also in fact in Chinese. And when you think of putting things in order, then you can immediately recognize that there are always going to be two special places in any order which are likely to be of particular interest: the **beginning** and the **end**. So in languages that **use** word order in this way, to show how the information is to be organized, it is almost always the first position in the clause and the last position in the clause that carry the main burden—the main 'functional load' as we call it. The two do not have the **same** significances of course; putting something first gives a very different flavour from putting it last. But it is through the combination of the two that our discourse comes to make sense.

Let us illustrate this now from the scientific discourse. (I am sorry that these illustrations are so long; but these are discourse effects that we are observing, and therefore, they involve whole stretches of our text.)

*According to this theory, all the operations of electricity depend upon one fluid sui generis, extremely subtle and elastic, dispersed through the pores of all bodies:*

*by which (bodies) the particles of it (the fluid) are as strongly attracted, as they are repelled by one another*

*The equilibrium being forcibly disturbed the mutual repulsion of the particles of the fluid is necessarily exerted to restore it.*

What this **packaging** does is to enable Priestley to make the whole of the message ‘particles of the fluid repel each other’ into a **single element in the clause**: *the mutual repulsion of the particles of the fluid*. Why?—because he wants the whole of that complex as a single piece of information. Why ...?—because he wants you to take it for granted; he is signalling to you that you have heard about it before, and it is now going to become the **point of departure** for a new step in the argument. If he had said *the particles of the fluid necessarily repel each other*, only the words *the particles of the fluid* would be in this first position in the clause—in THEMATIC position, as we call it; the message would be ‘I’m telling you something about the particles’. But he is not; he told us that already, and he is now going on from there to tell us something else, something **about** the fact that the particles repel each other—that this is necessary to restore the equilibrium. And the only way you can do this, in English, is by nominalizing; that is to say, by putting all the points together and turning them into a nominal group; so that is what Priestley has done.

So what scientific discourse does, in every language, is to exploit certain resources which are already there in the grammar, but to bring them out of hiding as it were, to exploit them in new ways and to new extents. This ability to package information and distribute it in appropriate ways in the clause is perhaps the most important single feature of written scientific English: without it is impossible to develop an argument. But in order to do it, we have to **objectify** everything: make events look as if they were objects. Again, take the example

*the particles of the fluid repel each other*

This is a process: *the particles of the fluid* are **doing** something,  
and that is how we would typically talk about it. But when we write

*the mutual repulsion of the particles of the fluid*

This process has been tied up with grammatical tape and has fixed; it becomes a **thing**. *Repulsion* is a grammatical metaphor, which makes the process of repelling (verb) look like an object (noun). Scientific language is amazingly rich in grammatical metaphor—and that is precisely why it can be so difficult to follow.

Moving on to the nineteenth century, let us take a look at the writing of James Clark Maxwell, one of the outstanding physicists of his time, a professor at Cambridge.

**Text 2.6: Extract from James Clark Maxwell, *An Elementary Treatise on Electricity* (1881)**

*The amount of heat which enters or leaves the body is measured by the product of the increase or diminution of entropy into the temperature at which it takes place.... The consequences which flow from this conjecture may be conveniently described by an extension of the term ‘entropy’ to electric phenomena.*

Here, we will find some features which are by now familiar—and also others coming into prominence for the first time. To start with the phenomena we have just been discussing in Priestley’s writing, notice

*the amount of heat which enters or leaves the body is measured by*

*the product of the increase or diminution of entropy into the temperature at which it takes place*

where *the amount of heat which enters or leaves the body* is again a thematic package referring (relating) back to the clause *heat has entered or left the body* in the preceding sentence. Note that there is an equally long nominalization—actually longer—at the end, after *is measured by*: a highly convoluted nominal group with masses of prepositional phrases in it. Such packages, in other words, are not only there for **thematic** purposes, i.e. at the beginning, but also for **news value**, i.e. at the end. Just as we put at the beginning of the clause the item the writer wants us to start with, to take as the Theme, the point of departure for the message, so we typically put at the end of the clause the item he wants us to attend to, because it is being given to us as a piece of news. We have heard before about heat entering or leaving the body; now we are being given some further new information about it.

But let us move on to another point, exemplified by the following two sentences:

*The entropy of a material system is the sum of the entropies of its parts.*

*The reversible portion of the thermo-electric effects are subject to the same condition as other reversible thermal operations.*

Throughout this passage, there are a few material processes: verbs such as *pass*, *emit* and *absorb* where some physical process is being referred to. Such verbs have been getting fewer and fewer ever since the Chaucer passage; they occur usually only in the description of experiments and have largely disappeared from scientific writing today. What then are the verbs doing? We have already begun to see what they are doing, in the writings of Newton and Priestley. So here with Maxwell:

1. Some are expressing opinions: *We have avoided making any assumption, we may make use of the idea of, always remembering that, we shall suppose, it is proved, we have great reason to conjecture.*
2. All the others are either the verb *be* or one that is related to it, and we must note here what the verb *to be* means, since it is by now the most important verb in scientific English.

The verb *be* has two basic senses. It either assigns something to a class, as in *Mary is a doctor, John is tall* (Mary belongs to the class of doctors, John belongs to the class of tall people), or else it gives an identity to something, as in *Mary is the doctor, John is the tallest one*. You can always tell the difference, because the ‘identity’ clauses can be turned round: you can say *the doctor is Mary, the tallest one is John*; whereas you cannot turn the attributive examples round: you cannot say *a doctor is Mary, tall is John*.

Both these kinds of *be* have been appearing in all our specimens from Chaucer onwards. Both likewise appear in this passage: the identifying *be* in the definition just quoted and in formulae, the attributive *be* in, for example:

*electricity is or is not a body; entropy is a quantity which ...*

*the thermal effects of electric currents are in part reversible and in part irreversible  
the reversible effects are small*

In addition to these uses, the verb *be* combines with prepositions to express circumstantial relations of one kind or another: *are subject to, are according to, is by means of, is due to*, etc.

Now, all these categories have other verbs with closely related meanings: attributive, e.g. *be, become, turn, stay, seem, look, sound, feel*; identifying, e.g. *be, represent, constitute, symbolize, signal, herald, reflect, mean, serve as, act as*; or circumstantial, e.g. *be at, be on, be about, cause, lead to, accompany, follow, produce, dictate, stimulate, demand, require, correspond to, apply to, arise from, flow from, cover, result from, be associated with, be measured by*. By the time of Maxwell, the range of meanings covered by verbs of this type had greatly extended, to the point where much of scientific discourse could be carried forward on the basis of these verbs alone.

These verbs express, not actions and events, nor mental processes—thoughts, feelings and so on—but **relations**: relations of attribution, identity, time, causality, similarity, etc., **between** one element and another. And this is the corollary to what we have just been witnessing. If all our happenings are turned into nouns, then by the same token—as part of the same metaphorical process—the relations between these happenings are turned into verbs. So in a school science textbook, instead of saying

*More people smoke, so more people die of cancer of the lung.*

the writer says

*Lung cancer death rates are clearly associated with increased smoking.*

where the verb *associated with* expresses a relation between two distinct processes.

That is the essence of the code our learners have to learn to crack.

So the language of science is functional, like every other kind of language; it has evolved to serve specific needs and specific tasks within society, under particular circumstances in the history of a culture. But, as usual with human institutions, there is a price that has to be paid.

Scientists themselves have been the first to recognize that their language has its limitations, though since they were not linguists, they have not usually understood these limitations very clearly. The pioneers of artificial languages, at the Royal Society in London at the time of Newton—those whose work led indirectly to Roget's *Thesaurus*, 150 years later—were partly motivated by the need for an international form of communication among all countries of Europe, now that Latin no longer was used to serve that purpose; but they also felt that existing languages (Latin itself, but also English, French, German, etc.) were not sufficiently rigorous in their structure, and particularly in their taxonomic organization of the vocabulary—a basic task of scientists at that time being that of classification, the classification of inorganic and organic matter, including all species of animals and plants; and they



felt that our words were used too loosely, so that languages did not provide an adequate resource for encoding and developing their knowledge.

More recently, scientists in our own century, from Einstein onwards, have registered exactly the opposite complaint. They feel that their language is too rigid, too absolute, too single-minded, unable to cope with the fact that the universe as they now see it is indeterminate, relative and fluctuating, so that we have to talk about happenings, the flow of things, rather than objects in a fixed state, and we have to accommodate at one and the same time what appear, from the way we express them in language, to be contradictory interpretations of reality.

These scientists do not know this, but in fact what they are asking is that their own scientific discourse should move rather closer to its origins in everyday language—to the kind of language that we (and this includes our children) use for our ordinary, commonsense encounters with each other and with our environment. Their own discourse—for very good reasons, as we saw—has become **too** ‘nouny’: it has cemented the flow of experience in which we live, made it seem static, as if changing was a special case instead of being the normal condition in which everything always is.

Here, we begin to see the price that has been paid. One aspect of this is simply the fact that scientific language **is** different. By growing apart in this way, scientific discourse has helped to widen the gap between educational experience and, everyday, commonsense experience. Of course, it is not only scientific discourse that has these properties: the language of bureaucracy also has moved in this direction to a far greater extent, and with far less justification: there is no **need** to write things such as:

*Policy also provides for the carriage of children on buses subject to available room*

instead of

*Children are allowed to travel on the buses provided there is enough room for them*

But the fact that these forms are characteristic of scientific writing does create a **distance**, for our children, between what they learn in school and what they learn, and know, of the world outside.

The other aspect of the price we pay is that which the scientists themselves are coming to recognize: that in order to ‘fix’ the world of the physical and biological sciences, to hold it still in order that it can be studied, the language has had (as I expressed it just now) to cement it: to make it look as though reality consists of a lot of things, fixed sets of objects in fixed relationships. That after all is what nouns, and nominal structures, suggest to us—they suggest this because that is why our languages **have** nouns: to talk about those phenomena that we recognize as **things**. Our everyday, commonsense language creates a world that is a balanced array of things (objects and their properties) on the one hand and of happenings, or processes (actions, events, behaviours, mental processes and relations **between** things) on the other. If we turn everything into nouns, we are building up a one-sided picture of reality, an interpretation of experience that is in conflict with how our ordinary language has led us to understand it. The world of everyday discourse is

very highly organized; but it is fluid and largely made up of events, whereas the world of scientific discourse is made to look like a construction of objects, the only ‘events’ being the relations that exist among them.

And finally—scientific language does tend to be somewhat ambiguous. This is something I have not touched on today; I shall be returning to it in later lectures, when looking at the language of the subjects studied in school. This may seem surprising, in view of its declared aims, and of the scientists’ complaints that it is too rigid; but we shall see that in order to **gain** meaning of one kind—the rhetorical (or textual) meaning that allows each message to be organized as a piece of information in a coherent, logically developing argument—it has had to **sacrifice** meaning of another kind, and this also makes it harder to understand. In the next lecture, I shall return to the perspective of the child, picking up where I left off, to ask how the natural, commonsense language (and the protolanguage before it) with which children have learnt to think about and to act upon the world leads into, and prepares them for, their experiences of learning in school.

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