scientists and much more besides. To act at a distance on (for instance) clinicians, the text thus assembles an array of resources that have the power to enforce a *whole world* within which the clinician is located. In other words, by their very nature texts reveal the complex structure of the actor-network as it seeks to translate others and thereby build a world.

Take the heterogeneous. Homogenise it to two dimensions. Juxtapose this homogeneity in a forceful textual structure. Send the structure out to act on others who will be likewise homogenised. This is the secret of the laboratory as an agent of change, a secret that involves building complex but enforceable worlds on paper. But the analyst who wishes to understand the struggles between actor-networks finds him/herself in a very privileged position. The structure of the worlds so built on paper are displayed for all to see. People may lie to us. Machines do not talk. But texts, once inscribed and diffused, cannot be changed. They may be rejected. They are, of course, also multi-interpretable. But for all that an essential part of their structure remains fixed and on display for all to see. How, then, does this ultimate textual weapon work? This is the subject of the next three chapters.

NOTES

1. For further ethnographic details see Williams and Law (1980); Law and Williams (1981, 1982); Law (1983); and Chapter 5 in this volume.
2. On the concept of translation, see Chapter 2 and also Callon (1980b).
3. On black boxes see Callon (1981b) and Law (1984b).
4. For another view of the importance of simplification in the laboratory see Star (1983).
5. For a seminal analysis of the role of inscription in science see Latour and Woolgar (1979). For a general analysis of the importance of texts and printing for social control see Latour (1985). For a study of the way in which texts, people and devices interact to generate power in science see Law (1985a).
6. On the capacity of the laboratory to act upon the world see also Latour (1983, 1984); Law (1984b).
7. See Law (1985d) for this point, developed in the entirely different context of Renaissance technology. See also Latour (1985).

4 Writing Science – Fact and Fiction:

The Analysis of the Process of Reality Construction Through the Application of Socio-Semiotic Methods to Scientific Texts[1]

BRUNO LATOUR and FRANÇOISE BASTIDE

Over the last fifteen years our conception of the scientific article has greatly advanced with the application of methods borrowed from history, literary criticism, rhetoric, semiotics, and finally, the microsociology of science and technology.[2] During the last few years, scientific discourse which was formerly thought to be inaccessible to laymen or written 'without literary style', has become an almost routine subject for literary criticism. In this chapter we demonstrate some of the results of these studies experimentally.

Our aim is to highlight some of the methods used by scientists to create a forceful textual structure, one that will carry weight when those who wrote it are no longer physically present to argue their case. Our chosen method is to alter a few texts in such a way that the reader can feel the different effects provoked by these modifications. We then briefly comment on the significance of these effects.

EFFECT 1: DECIDING ON HISTORY AND EPISTEMOLOGY

'Evidence for a process of counter-current water exchange in the inner regions of the hamster kidney'
by F. F. François, R. Maxime and C. Claude
Biology Department, Atomic Energy Commission. Received 22 March 1960.

[1] Over the last few years, our conception of the mechanisms of urine concentration in the kidney has greatly advanced following experimental observations by Wirz, Hargitay and Kuhn (1951) and their interpretation.

[2] In spite of the experimental observations of Wirz, Hargitay and Kuhn (1951), our understanding of the mechanisms of urine concentration by the kidney has evolved little over the last few years. Recently, however, a new interpretation of their results has sparked off decisive advances in our knowledge on the subject. This interpretation has brought to light the process of counter-current water exchange.

In paragraph [1], the flow of events is suddenly interrupted by the appearance of 'greatly advanced' conceptions. The cause of these advances is attributed to the works of three people, 'Wirz *et al.*' Finally, as is usually the case in classic epistemology, a distance is established between 'observation' and 'interpretation'. In paragraph [2] this same distance is maintained but is used to deny that 'Wirz *et al.*' are responsible for the 'greatly advanced conceptions'. The 'observations' had no value before a new interpretation explained and made sense of them. The rhythm is altered for it is the authors of the article, not Wirz *et al.*, who instigate the change.

Thus in three lines an article already expresses a history of science and an epistemology. It also distributes responsibility for this history. To go from form [1] to form [2] obviously requires lengthy discussion and arduous negotiations between the authors, and then between the authors and the referees. These negotiations are marked by erasures, interpolations and additions in the successive rough drafts (Knorr-Cetina, 1981; Williams and Law, 1980; Lynch, 1982).

EFFECT 2: SETTING UP A NEW SCENARIO

[3] The procession slowly progressed through the winding streets of the old city. From high up in the belfry, I was easily able to distinguish the little scouts, the musicians of the Sons of France, and the men from the church council carrying the canopy. The crowd was lined along each pavement and although most were only Sunday believers, they listened quietly as the Daughters of Mary passed praying. However I noticed that at every street corner the scouts, who were impatient to get a bite to eat at the chaplain's headquarters, threaded their way with difficulty through the loiterers. They passed from one street to the next, shortcutting the procession, and then dispersed towards the fun fair. Moving from the main streets to the alleys, the procession lost its children and, little by little, was whittled down to a core of pious but middle-aged souls.

[4] The results detailed can be perfectly explained if one accepts the hypothesis that the walls of the vascular and urinary hairpins are much more permeable to water than to sodium. This would generate a counter-current water exchange between the ascending and descending limbs. If the walls of the ducts are more permeable to water, 'transversal diffusion' should cause a fraction of marked water molecules circulating in the descending limbs to pass into the ascending ones by exchange at each level.

These two paragraphs construct an observer, one in his belfry and the other in his laboratory. These observers are assumed to have witnessed a phenomenon which has the same form:

hamster kidney	old city
counter-current hairpins	winding alleys
duct walls	assembled crowd

A mixed set of elements circulates in this general decor: on the one hand, marked and unmarked water and sodium, and on the other, a procession. In both cases the crowd becomes differentiated and concentrated into either sodium at the turn of the hairpins or pious middle-aged souls at the end of the day. In both cases the sodium and the Daughters of Mary remain true to the course whereas the water and the little boys pass respectively through the walls and the crowd and move off.

Neither paragraph is more concrete, technical or simple than the other. 'Sons of France' is a local term known only to the natives of Beaune. As for the 'church council', it is certainly no better known than 'sodium'. Though few people have dissected the ducts of a kidney or observed the functioning of a system of counter-current water exchange in urine, how many Frenchmen have seen a Corpus Christi procession from a belfry? As for the separation between religious fervour and the desire to get a snack, no more is said of this than about the wall that holds sodium in but lets water through.

In both paragraphs a certain degree of concentration must be revealed to the observer and then to the reader. The first observer climbs up into his belfry and tells us what he sees, while the second descends by stages into the kidney and reports what he has observed.

At this point, though, the two observers take totally different routes. To see the layout and the flow of the old city, the first observer takes advantage of Corpus Christi. He sees the procession take place directly as a continuous event unfolding in time and space. The second observer sees nothing. The kidney is too obscure. He must create the event, build time and space, and reconstitute the actual continuous movement from discontinuous observations.

To create the event, the observer must introduce radioactive water and sodium where unmarked water and sodium usually flow. The kidney will not know the difference but the observer will. Just as with the brown shorts of the Boy Scouts and blue uniforms of the Daughters of Mary, the radioactive water and sodium mark a contrast. The relative concentrations of elements thus become visible. Of course, we still do not see anything but at least we can subtract one quantity from another.

This is not enough to construct a narrative. The person who wants to observe something happening in the kidney must create the movement of his invisible procession by superimposing photo finishes. Just as those who organise car rallies place tallymen at predetermined points along the course, the observer systematically slices the kidney into eight segments from the cortex to the papilla. Since it is impossible to follow the flow through a kidney cut into sections, the observer must start the procession in several kidneys and then interrupt the flow each time after an increasingly long interval. The still-life story of displacement is then recounted on a table.

EFFECT 3: SETTING UP INSCRIPTION DEVICES

The observer in the belfry of paragraph [3] saw the little brown spots passing through the crowd but the reader only saw a text saying that the author had seen them. Unlike the first observer, the second refers his reader to a figure (Figure 4.1) which is explained by a legend which then refers the reader to a table (Table 4.1). This double entry table is a record of what happened in the laboratory. It is obviously much more difficult to bring the counter-current to light. What do we actually see in Figure 4.1? Literally speaking, we see a comic strip. That is to say, time passes from left to right. This is an accepted convention that is easily adopted

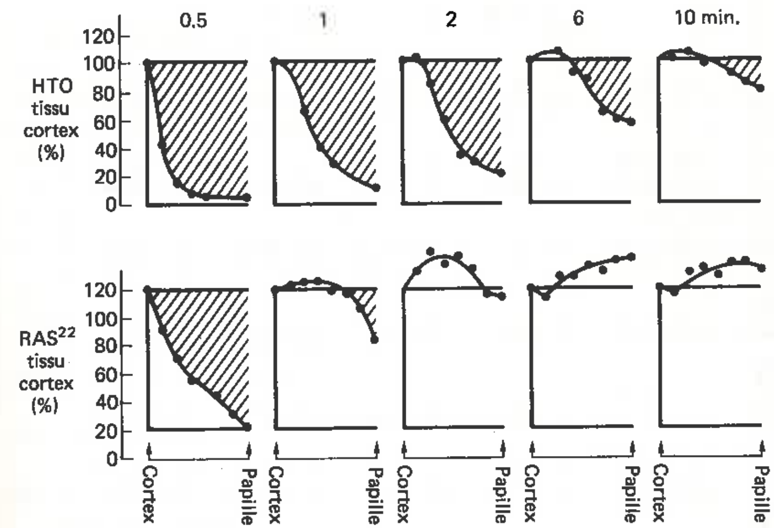

FIGURE 4.1 Turnover, with time, of water and sodium in the different regions of the kidney (redrawn from the original).
Abscissa: the different regions of the kidney as defined in Table 4.1.
Ordinates: top: the radioactivity of tissue water (i.p.m./mg) expressed as a percentage of that in the cortex; bottom: the specific radioactivity of sodium (i.p.m./µg Na) expressed as a percentage of that in the cortex. The numbers at the top of the figure indicate for each curve the time interval (min) between the injection of the isotopes and the removal of the kidney.

when reading 'Peanuts'. The event to be described in this comic strip is a decrease in the hatched surface limited by a curve. 'Everyone' is able to see that the surface diminshes from left to right. As any 10-year-old can tell, every drawing in this comic strip is also coded according to its abscissa and ordinates. The abscissa goes from the surface to the inner regions of the kidney or, for the anatomists, from the cortex to the papilla. For the ordinate, there is a scale going from 0 to 120 which would pose equally few problems since everyone knows how to read a thermometer at least.

Using such simple reading conventions, the drawings nevertheless become fairly difficult to understand. 'Everyone' can read each element but the sum of them all is easily legible to perhaps ten people. The two strips are not to be read as a continuous sequence but in contrast to one

TABLE 4.1 *C Cortex. J Cortico-medullar junction. MR1, MR2, MR3 red medulla (external). MB1, MB2: white medulla (internal) BP: Base papilla. Pl: Plasma.*

Expérience du 17 juillet 1959 Hamster (96 g) temps écoulé 0.5 min	HTO i.p.m./mg tissu frais × 10^{-2}	31.5	13.2	4.5	2.2	1.8	2.0	2.0	1.9	
	^{23}Na μg/mg tissu frais	1.4	2.6	3.4	4.4	5.4	8.3	7.4	8.9	
	^{22}Na i.p.m./mg tissu frais × 10^{-2}	3.9	5.1	4.9	4.5	5.2	6.1	2.4	0.7	
Expérience du 31 juillet 1959 Hamster (108 g) Temps écoulé 1 min	HTO i.p.m./mg tissu frais × 10^{-2}	17.1	16.9	11.3	6.8	4.8	2.5	3.1	2.2	12.2
	^{23}Na μg/mg tissu frais	1.7	2.3	3.1	3.8	4.3	5.6	6.2	7.8	3.1
	^{22}Na i.p.m./mg tissu frais × 10^{-2}	2.7	4.2	5.9	7.1	7.5	9.6	9.6	8.9	3.8
Expérience du 10 juillet 1959 Hamster (110 g) Temps écoulé 2 min	HTO i.p.m./mg tissu frais × 10^{-2}	15.8	16.2	13.1	9.4	5.4	4.7	3.9	3.3	9.7
	^{23}Na μg/mg tissu frais	1.7	2.7	3.4	4.6	5.7	7.9	8.1	3.7	
	^{22}Na i.p.m./mg tissu frais × 10^{-2}	2.1	3.6	5.0	6.3	8.4	10.5	10.7	11.5	3.1
Expérience du 16 juillet 1959 Hamster (96 g) Temps écoulé 6 min	HTO i.p.m./mg tissu frais × 10^{-2}	6.8	7.0	7.3	6.3	5.9	4.4	4.2	3.9	7.6
	^{23}Na μg/mg tissu frais	1.4	2.8	3.1	4.1	4.8	5.9	6.7	7.0	3.7
	^{22}Na i.p.m./mg tissu frais × 10^{-2}	1.3	2.3	3.2	4.2	5.3	6.2	7.6	8.2	1.9
Expérience du 31 juillet 1959 Hamster (120 g) Temps écoulé 10 min	HTO i.p.m./mg tissu frais × 10^{-2}	7.1	7.1	7.7	6.9	7.2	6.5	6.1	5.7	6.2
	^{23}Na μg/mg tissu frais	1.7	2.7	3.3	4.1	5.4	5.3	6.0	7.7	3.4
	^{22}Na i.p.m./mg tissu frais × 10^{-2}	1.1	1.6	2.3	2.9	3.6	3.9	4.4	5.4	2.1

another. The upper strip describes the passage of marked water, the lower of marked sodium. To get used to reading this figure one must, as in gymnastics, undertake a series of simple movements. Each image is first read as a curve according to its abscissa and ordinate. Then the five images are read as a time sequence (towards the right). Each strip is then read in comparison with the other (from top to bottom and bottom to top). Finally, each point on the curve is transformed into the positions of the elements that travel through the hamster's kidney. This figure is neither simple nor difficult. Nor is it easy or difficult to read. According to the legend, if we agree to read it, the figure is either as 'plain as day' or 'means nothing at all'.

The legend, as the name indicates, tells us what we should see in this story of procession and sacrifice:

(a) The area diminishes from left to right and diminishes more rapidly at the top than at the bottom.
(b) In the inner regions of the kidney, the water is renewed less quickly than the sodium.
(c) Thus we see a delay. The water takes a shortcut.
(d) A counter-current is revealed.

We can question what the author claims to have shown in two ways. We can either accept the figure but refuse to go to a level higher and refer to the sense of the legend, or we can ignore the figure and go to a lower level by referring directly to the experiment.

For the first case, the reader can say that he sees the areas diminish but cannot see any 'delay', even less a 'counter-current'. He can thus say that the figure 'proves nothing'. He therefore challenges the series of transformations that allow one to pass unequivocally from the comic strip to the process of counter-current water exchange.

In the second case, the reader can challenge the figure at a lower level and deny that the points of each graph correspond to anything. That is why the authors refer the (potential) reader to the table.

The table makes use of the same visual oppositions as the figure but in a different order. The top and bottom now correspond to a reclassification of the experiments in relation to the time interval between injection and removal. Left and right now correspond to a display of the kidney slice in relation to anatomical reference points. To make sense out of the table, one must undertake a series of subtractions. It contains many more details but shows less than the figure. Nonetheless, the figure is completely dependent upon the table. It cuts out one column from the table and reduces the quantity of numbers. As a result of a series of transformations, certain ratios are established that lead to percentages. The authors therefore transform the discontinuous subtractions into a continuous reading of surfaces. Thus the reader sees things in the figure that he does not see in the table. However, if the reader is suspicious of the figure, he has to trust the table. The table consists of indices that refer to an outside world (the laboratory) where certain events seem to have actually occurred: 'Expérience du 17 juillet 1959; Hamster (96 g); Temps écoulé: 0.5 min'. The empty boxes in the columns indicate the presence of errors and uncertainties. The table is full of little details that make it look real. Unlike the illustrations that accompany normal narratives, the figure is not based on an 'external' source but only on a table which in turn confusedly points towards the world of the laboratory. Reaching this point, the reader still sees no more than when he read the narrative of the observer in the belfry. He still simply has to believe the author.

EFFECT 4: NEGOTIATING THE TEXT

[5] Figure 4.1 shows that tritiated water and radio-sodium behave differently within the inner regions of the kidney. The surface of the hatched zones for each time period is in proportion to the quantities of water and sodium that have yet to reach equilibrium with the cortex. This surface diminishes with time but follows a rather different path for water than for sodium. Indeed, ten minutes after the injection of the indicators, the concentration of tritiated water in the innermost regions is still less than that in the cortex. This indicates that in the inner regions of the kidney the renewal of water is much slower than for sodium.

The written text of the article is a verbal commentary on the figure, just as Figure 4.1 is a visual commentary on the table. After having seen the table and read the legend we should now be able to understand the written explanation. Paragraph [5] aligns a series of equivalents so that one is able to go from simple drawings to the hamster kidney. In seeing Figure 4.1, it is as if we were seeing the functioning kidney in the hamster. According to the text, the hatched zone is/represents/figures/is worth the same as the 'quantities of water'. The 'rather different' paths are/represent/figure/worth the same as 'the delay' which in turn 'reveals' the counter-current in exchange.

The text of the article does not say anything that it fails to show. It

does not show anything that is not supported by the data. Nevertheless, it does not actually show anything. It builds a chain of transformations that makes it possible for us to tie the discovery of a counter-current to a hamster in oliguria sacrificed at the other end of a chain on 17 July 1959 at the Biology Department of the Atomic Energy Commission. The text shows everything and the text shows nothing. What then does it show? It presents traces, inscriptions, and prints in which lots of things are said that are summarised in one sentence by the title. Does a scientific text tell a story like other kinds of texts? No, because it stacks the traces in such a way that each one is a transformation of the last. So does it therefore constantly repeat itself since it talks about the same hamsters ten times in a row? No, because it adds something each time which is not really shown but then is not really unfounded either. The text puts together its elements as if they were stones in a primitive arch. Each one is supported by the last but leans out into the void. Yes, it is a construction. Is it fragile? Sturdy? That depends upon the masons, the thrust it must sustain, and the fit. But mostly it depends upon the negotiations which guide the way in which each stone is balanced upon the last. Too much timidity and the article will never be finished. Too much audacity and it will crumble.

EFFECT 5: FORECLOSING OBJECTIONS

[6] Scientific objector no. 1: 'If the kidneys are not immediately frozen the isotopes will diffuse everywhere and the measurements will be meaningless.'
Materials and Methods, line 9: 'The excised kidneys are *immediately* immersed in liquid nitrogen.'
Scientific objector no. 2: 'But that's not good enough! If the razor used to cut the frozen kidneys is warm, you will disturb the results!'
Materials and Methods, line 12: 'Each kidney is then dissected in a cold room (– 5°C) to avoid any thawing. A segment spanning the whole of the kidney from the papilla to the cortex is prepared using a chilled razor blade.'
Scientific objector no. 3: 'In any case, you'll have to thaw the kidneys sooner or later to prepare your samples and then the radioactive vapour will evaporate.'
Materials and Methods, line 19: 'These frozen fragments are placed in pyrex tubes that are immediately capped with an airtight stopper made of aluminium foil.'

Scientific objector no. 4: 'Yeah, but they'll have to be uncapped so that whatever solvent you want to add can be introduced.'
Materials and Methods, line 25: 'The tubes are weighed and then 1 ml of distilled water is injected through the aluminium foil with a precision syringe. With this precaution it is possible to avoid having to uncap the test tubes and thus lose highly radioactive water vapour originating from the labelled water in the tissue that has been removed.'
Scientific objector no. 5: 'You don't know what you're doing! You haven't even ground up the tissues! How can you be sure that the labelled sodium and water will be completely equilibrated within the solvent, huh?'
Materials and Methods, line 25: 'The small size of the fragments (2–10 mg) allows labelled water and tissular electrolytes to diffuse quite rapidly in the supernatant where they can be measured.'

Paragraph [6] introduces a fictitious dialogue between either the author and his 'dear colleagues' or between him and his superego(s). We have moved, therefore, from the text to a dispute about where the text comes from. It is here that we reach a weak point, the Achilles' heel, of the whole article. This Colossus may have feet of clay, this counter-current may flow through a paper kidney. Thus the table is supported by another section which is written in prose and in small print. This section has long been known as Materials and Methods. It is the most polemical section of the entire article, but it is a polemic that is so intense that it ends up looking very boring.

Imagine that, in order to convince us, the authors had only presented the numbers in Table 4.1. After all, that should have been good enough. These authors seem to have been honest and we should have been able to trust them. However, had this happened, we would have immediately heard an outcry of indignation and protest. Where do your numbers come from? What is their genealogy? How did you remove the kidneys? What was the temperature of the razor? Were the tubes tightly capped? Each of these colleagues' questions points at a gesture to be made, a precaution to take, an instrument to buy and a skill that is needed. All of these are absolutely necessary if one wants to be able to lead a hamster kidney to reveal its functioning. It is as if someone were making a long water hose by connecting several shorter ones together. One knot, one defective joint, one leak and not a single drop of water will spout from the nozzle. It is only through similar joints that the operation of the kidney is revealed. If one breaks down, the colleague will never be convinced.

Will the colleagues be told everything or nothing? Compromise! Everything that is routine can be left out. So can secret recipes. There is no point in explaining that one must wear cotton gloves when weighing the kidney fragments so that sweat from fingers does not upset the measurements. These are little habits that we learn in good laboratories, just like those little secrets that are taught by great chefs. However, each time the absence of a precaution turns the hamster kidney into soup and causes a cloud of obscure numbers to come pouring out of the end of the hose, the Materials and Methods section should indicate that the relevant precaution has been taken. Although the style used in this section seems forbidding, behind every good adjective and noun hides a sharp-eyed critic for whom these are passwords. Reassured, he allows the author to continue to the next precaution just as the guards manning a series of checkpoints at the entrance to a fortress allow a caravan to enter. If the author makes it all the way through, the numbers inscribed in Table 4.1 will be accepted and the reader will finally start discussing their meaning.

According to Nietzsche, the desire not to want to deceive others is the same as the desire not to want to deceive oneself. It is the author that imposes upon himself the most gruelling of trials. For example, the article contains a little-used section titled 'critique of the methodology'. This section is a self-critique.

[7] It seemed appropriate to standardise the results with respect to the cortex sample because:

(a) some plasma samples were taken under poor conditions especially for the shorter time intervals where the delay between kidney removal and blood sampling could be an important source of error;

(b) cortex samples were treated in exactly the same way as those from other regions. They are therefore subject to the same causes of experimental fluctuation as the other samples.

It would have been nicer to relate the specific radioactivities of the isotopes in the kidney to their values in the plasma (which is what almost 'everyone' does!). But the plasma values which correspond to the shortest time intervals are missing from the table. No doubt they exist in the lab notebooks but they 'make no sense'. To deal with these results one must omit them as if they were the product of an unfortunate fluke. *Felix culpa* . . . this tell-tale accident allows one to 'standardise' the results in a prettier way. It allows one to smooth out the curves more successfully since the presumed sources of error compensate for one another as is indicated by point (b). This sort of self-critique most certainly contributes to the authors' honourable position. The reader will trust the results because the author anticipated not only his objections but also answered in advance questions of which the reader would not have dreamed. Who could now doubt the author or his overprotected results?

If anyone was still suspicious, he would not yet be referred from the texts to the actual laboratory practices, but rather from the text to others. These are only shown to close friends or reopened during investigations into rare cases of fraud. The lab notebooks and experimental records hold details of all the precautions taken, all the failures, and all the red herrings pursued. Someone in doubt over the numbers and the experiments could dive further into the book-keeping to prove that a certain experiment actually did take place, that a certain lab assistant was present that day, or that the animal keeper had in fact taken the water bottle away from the hamsters in order to put them in oliguria. The doubt will subside long before the stack of written traces runs out.

The more colleagues there are, the more the traces proliferate and pile up. If the cheat wants to conceal his cheating, he will even have to falsify his protocol books more and more cleverly (Bastide, 1981a). He will be prevented from fraud because of the extreme suspiciousness of his fellow colleagues. Actually he will have to be so clever that he will become, yes, an honest researcher just like the others.

EFFECT 6: TRIAL BY ORDEAL

[8] Pierre and Marie Curie (PMC): 'Here is the new hero emerging from this mixture, pitchblende, you see? It makes the air become conductive. You can even measure its activity with the instrument that Pierre devised, a quartz electrometer, right here. This is how we follow our hero's fate through all his ordeals and tribulations.'
Objector (O): 'This is not new, uranium and thorium are also active.'
PMC: 'Yes, but when you attack the mixture with acids, you get a liquor. Then, when you treat this liquor with sulphuretted hydrogen, uranium and thorium stay with the liquor, while our young hero is precipitated as a sulphuride.'
O: 'What does this prove? Lead, bismuth, copper, arsenic, antimony, all pass this test as well, and are also precipitated!'
PMC: 'Ah!, ah! But, if you try to dissolve them all in ammonium sulphuride the active something resists . . .'

O: 'OK, OK. It isn't arsenic, nor antimony, but it might be any one of the old heroes, lead, copper or bismuth.'
PMC: 'Impossible, my dear, since lead is precipitated by sulphuric acid while the hero stays in solution; as for copper, ammoniac precipitates that.'
O: 'So what? This means that your so-called "active substance" is simply bismuth. It adds a property to good old bismuth, that of activity. It does not define a new substance.'
PMC: 'It does not? Well, tell us what will make you accept that there is a new substance?'
O: 'Simply show me one trial to which bismuth reacts differently from your "hero" . . .'
PMC: 'Simply heat sulphur in a Boheme tube, under vacuum, at 700°C. And what happens? Bismuth stays in the hottest area of the tube, while a strange black (soot) gathers in the cooler areas. This is more active than the material with which you started. And you know what? If you do this several times, the "something" ends up being 400 times more active than uranium!'
O: . . .
PMC: 'We therefore believe that the substance we have extracted from pitchblende is an hitherto unknown metal. If the existence of this new metal is confirmed we propose to name it polonium after Marie's native country.'

When sent from the text to the laboratories, from the paper world to the material world, the scientific objectors are used not only to give solidity to the argument. They are also used to define new objects. What are these famous 'things' which are said to lie behind the texts? First, a list of victories. 'Polonium' won a series of trials in the Curies' laboratory at the École de Chimie before it becomes a 'thing out there'; it defeated uranium and thorium in the sulphuretted hydrogen game; it defeated antimony and arsenic at the ammonium sulphur game; and then forced lead and copper to throw in the towel; only bismuth went all the way to the semi-final, but it too was beaten during the final game about heat and cold! At the beginning of its definition, the 'thing' is a score-board for a series of trials. Some of these trials are imposed on it either by scientific objectors and tradition – to define for instance what is a metal – or tailored by the authors of the paper – like the last game about heat and cold. The point is that, at its inception, a thing is nothing but this list of scores.

The 'things behind' the scientific texts are thus similar to the heroes of a fairy tale. All of them are defined only by their performances: defeating the ugly seven-headed dragon; resisting precipitation; saving the King's daughter against all odds; finding one's way out of the tortuous kidney ducts; following Ariadne's thread out of the labyrinth, and so on ... Each of these performances defines what the hero does; in the beginning there is no other way to know his essence. However, this does not last long because each performance presupposes a competence which, from the start, retrospectively explains why the hero withstood all the ordeals. The hero is no longer a scoreboard of actions; he is an essence slowly unveiled by each of his manifestations. Once polonium is accepted as an element the meaning of the list above changes dramatically: before, it was what made the new polonium exist inside the laboratory of Pierre and Marie Curie; afterwards, it becomes the agent that revealed the essence of an everpresent substance observed by the Curies.

EFFECT 7: THE FATE OF A CLAIM IS IN THE HANDS OF THE READER

[9] Evidence for counter-current water exchange in the inner regions of the hamster kidney.

[10] 'If François *et al.* have shown a counter-current water exchange, they did not provide a physiological explanation for the dissipation of the osmotic pressure gradient at the onset of diluted urine production. The present article shows measurements of the rate of water renewal under conditions of osmotic diuresis induced with mannitol.'

[11] 'François *et el.* claim to have shown a process of counter-current water exchange but their experiments are based on the use of hamster kidneys whose papilla are very long. It is precisely this characteristic that prevents us from extending their results to the kidneys of other mammals.'

[12] 'Shown? Shown? Well that was quick. OK, so they cut up kidneys. They sprinkled on some radioactivity which probably made their hands peel. But what does that prove? Have you read their articles? There's a difference between two curves and that's all there is. If you ask me, the rest is nothing but rhetoric. So far as hamsters are concerned, they don't get much of a look in at all.'

[13] 'Mammal kidneys possess counter-current water exchange that prevents the dissipation of the sodium gradient which serves to concentrate urine.'

The scientific article is read by other writers who cite it, discuss it, ignore it, suppress it, or believe it. Paragraph [9] describes what the authors claim to have accomplished. But will it be believed? The history of science is no more predictable than history itself. The outcome depends on gathering other authors/readers, and on what they find to disagree with.

The author of paragraph [10] believes what our physiologists have said so that he can move directly on to another problem: how the gradient of osmotic pressure vanishes. The more credible an article is, the more rapidly it can be redeployed to deal with another question. As in paragraph [2] where the authors claim 'decisive advances' for themselves, the author of paragraph [10] suggests that the others have not found all the elements of the solution.

Paragraph [11] is even more cruel. The article is not challenged but the extension that the authors could have claimed if no other colleagues had been present, is denied. The problem of induction is not as important as it appears. Without [11], nothing would have prevented François *et al.* from passing effortlessly from hamsters to all mammals. Conversely, if the competitors had been fiercer and our physiologists less well armed, they could have reduced the article to forty slices from five hamster kidneys! There is no limit to the degree of induction. It depends on might not right.

The person interviewed in paragraph [12] is a boor who denies any relationship between François's article and the hamster kidney. From this excerpt, it is apparent that relativism and the problem of reality is no more a philosophical question than that of induction. It is rather a trial of strength to be settled in action! If [12] is true then [9] is but an artefact. If [9] is true then [12] is nothing but the exaggerated bluster of a half-wit. On the other hand, paragraph [13], which is taken from a textbook, concedes so much reality to sentence [9] that there is no indication that it may be disputable or that someone has actually discovered it. That which is real and that which is not depends on each author, or rather, on what each author does with all the articles that preceded his own. The final degree of conviction is thus a mass effect.

With each text the reality of all those who are cited or ignored either grows or diminishes. There is no point is discussing an 'exact representation' of the operation of the hamster kidney. This appears at the end of a battle when everything has been played out. The 'exact representation' is the particular literary effect produced by the textbook. In scientific literature, 'demonstration' is a rare alignment of procedures, gestures, inscriptions and paragraphs that advances as slowly as the monstrance at the Corpus Christi procession. By going from five hamster kidneys to the 'operation of kidneys in mammals' and then back to the particular hamsters sacrificed above, a representation is displayed.

The representation of reality is one result among others, built sentence by sentence in laboratories and scientific articles which can be deconstructed sentence after sentence by the sociologist or semiotician who reads scientific articles: *quod erat monstrandum*.

NOTES

1. A preliminary and uncorrected version of this article has appeared without the authors' final approval in *Études Françaises*, 19 February 1984, pp. 114–33.
2. A few historians of science have been interested in the ways scientists were writing, and especially rewriting, their texts: for instance Koyré (1968) on Newton, Grmek (1973) on Claude Bernard, Feyerabend (1975) on Galileo. What a few scientists had said, that science was a form of writing fiction and not a direct rendering of Nature (Medawar, 1964) has been confirmed by discourse analysts (Gilbert and Mulkay, 1984; Woolgar, 1976, 1980) and by semiotic studies (Latour and Fabbri, 1977; Latour and Woolgar, 1979; Bastide, 1979, 1980, 1981a, 1981b, 1981c). Laboratory studies have, of course, encountered the problem of papers and paper construction (Latour and Woolgar, 1979; Knorr-Cetina, 1981; Lynch, 1985; Law and Williams, 1982) integrating this problem in the precise setting of laboratory practices. Two other notions are germane to these studies: that of rhetoric (Perelman, 1970; applied to science by Gusfield, 1976), and that of style (Granger, 1968). A few linguists have studied the structure of scientific texts (Gopnik, 1972; Lofflet-Laurian, 1980). Several specialists coming from literature studies have found the scientific text interesting as a genre (Bazerman, 1981, 1984; Yearley, 1981). The study of the visual aspects of scientific literature is less developed but there are some interesting exceptions (Ivins, 1938, 1973; Goody, 1980; Ong, 1982; Jacobi, 1982). Most of them are gathered or reviewed in Latour, 1985. Finally, there has been a mounting interest in scientific literature at the junction of the history of the publishing industry and that of science (Eisenstein, 1979; Meadows, 1980; Anderson *et al.*, 1983).

5 The Heterogeneity of Texts

JOHN LAW

INTRODUCTION

The text is the secret weapon of science. It is sent out from the laboratory and, if it does not strike terror into the hearts of those who read it, at least they are often obliged to take it seriously. By virtue of its transportability, its durability and its structure, it is often able to operate as a relatively autonomous agent thousands of miles from those who sent it out.

In Chapter 4, Latour and Bastide examined some of the ways in which the text obtains its power. Their approach was to create what may be called a 'semiotic reader', a fictional reader who is interested in the text but who is also radically sceptical. The effects that they described may be seen as textual methods of translation that are designed to force this reader into the laboratory in the pursuit of scepticism. They are, in other words, designed to prevent a reader who is interested in the argument from picking holes therein. However, as all those who set pen to paper know, this is only half of the battle. Before the sceptic can be convinced, it is first necessary that he or she should be *interested*. The reader has, in other words, to be sucked into the series of translations that will, if scepticism is pressed to its ultimate extreme, lead back into the laboratory. The problem, then, of making the paper attractive, of finding a journal that will publish it, of discovering or building a readership, is crucial both to individual scientific success and the capacity of certain texts to exercise power at a distance. It is this question that is addressed in the present chapter.

This problem is approached by considering an empirical example and looking at the way in which a particular group of scientists have sought to build an actor-world via the agency of a particular text. The argument falls into two main parts. First there is the question of *where* scientists