

The resurgence of science in France

The Socialist government of France has indeed done wonders for the health and achievement of French research, but there is a raft of problems — some of them long-standing — still to be resolved.

FRANCE, once the most conservative country in Europe, has become a land of technology buffs. People reserve seats on the high-speed trains whizzing everywhere (as well as theatre tickets) by Minitel, the domestic video-tex machines that have swept the country — and which could not have functioned if the telephone system had not been superbly modernized in just ten years. France has also provided the impetus for the creation of the only civil aircraft manufacturer outside the United States capable of selling civil aircraft to the world's airlines. Now it is seeking to drag its European partners into space. What has brought about this transformation? Do its roots lie in the election of François Mitterrand's Socialist government in 1981, and in its deliberate and daring programme to reinvigorate science and technology?

Neither the nature of the transformation nor the importance of its apparent cause should be exaggerated. France remains the Western European state most apt (and able) to claim to be the custodian of European civilization. (The cuisine is merely a by-product.) And technology has not ruined the delectable appearance of France, only some of it. (Too many city mayors have commemorated themselves with ungainly blocks of concrete in mediaeval settings.) Civilization does not, of course, equate with civility, but with respect for the law (including the Revolution's slogan), for intellectual discourse and the importance of the imagination.

The impetus for change in the 1980s is also a prolongation of earlier tendencies. How could it be otherwise when even provincial street names commemorate Descartes, d'Alambert, Pasteur, the Curies (both of them) and the like? The modernization of French science and technology began with the Gaullist government of 1958 and with the creation of the Délégué Général de la Recherche Scientifique et Technique (DGRST), which rapidly transformed itself into a kind of unestablished ministry of science.

Much of the Gaullist government's support for science and technology sprang from its preoccupation with the military defence of France, but that is when modernization began in earnest. The decision in 1981 that the budget for civil research should increase by more than 16 per cent a year was but the arithmetical consequence of the decision that civil research and development should be 2.5 per cent of Gross Domestic Product by 1985. The name to conjure with is that of Jean-Pierre Chevènement, Mitterrand's first minister of research and industry, now defence minister in Mitterrand's second Socialist government.

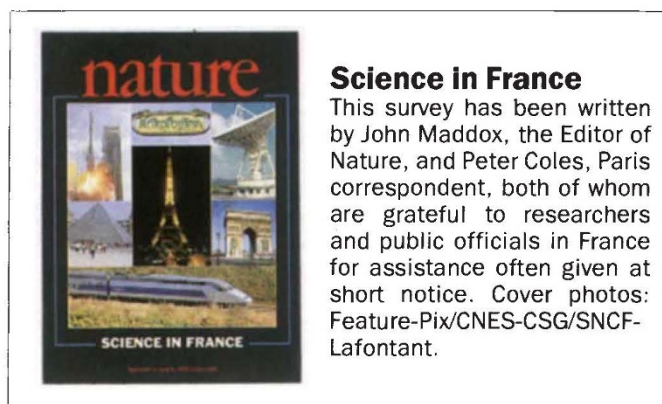
The timing of this survey of French science is deliber-

ate: it may not be too soon to estimate the outcome of what an earlier survey (*Nature* 296, 285; 1982) called "the grand experiment". The outcome should be of interest not only in France but elsewhere, in Britain for example, where governments have taken a more jaundiced view of the benefits of public support for research. But the method of this survey differs from that of earlier exercises of this kind. What follows is not an account of the well-known centres of excellence in France, but is based on conversations (often informal) with working scientists in France and elsewhere, as well as on documents in the public domain.

The good news is quickly stated. In the past eight years, there has been a quite remarkable deepening and broadening of basic research in France. Everybody knows of research groups in France with long-standing international reputations — the mathematicians of Nancy and Marseille, particle physicists at Orsay, solid-state physicists at Grenoble and Strasbourg, molecular biologists at Paris, the Pasteur institutes and Strasbourg, genome mappers and geophysicists at Paris, chemists almost everywhere. The psychological effect of the grand experiment is that all research groups can now realistically aspire to excellence of that kind. And most seem to have that ambition, as well as the enthusiasm that may overcome the usual bureaucratic obstacles.

Two other features of the transformation stand out. First, French researchers seem finally to have buried chauvinism in the search for international collaboration. A united Europe, in particular, is now, not tomorrow. Second, more by accident than design, the French government has engineered a bridge between basic and industrial research that is well designed to keep the technological revolution bubbling away in France.

That is the good news. Some of the bad news will be found on the pages following. □



Science in France

This survey has been written by John Maddox, the Editor of *Nature*, and Peter Coles, Paris correspondent, both of whom are grateful to researchers and public officials in France for assistance often given at short notice. Cover photos: Feature-Pix/CNES-CSG/SNCF-Lafontant.

Flies in the ointment

FRENCH research has been a great success, but there are structural weaknesses in the system that cry out for attention. French science is in better shape now than ever, so why is there so much talk of emergency, even crisis? One of the strangest features of France's distinctively explicit way of managing research — every major item of public expenditure is explicitly analysed in advance — is the recognition that rationality can often be the harbinger of muddle.

What follows is a stark list of those features of the research enterprise in France that cry out for attention. To the extent that they amount to complaints against the present system, they represent either the opinions of working scientists or are administrative faults acknowledged as such by the managers of the system.

It is important for an understanding of what should now be done that most working scientists are employed directly by the national government. This applies both to those who work for the *grandes organismes* of research (organizations such as CNRS), who acquired the status of civil servants in the early 1980s, and to those who are university teachers. Only during the past decade has the number of technical people working for industrial companies shown signs of substantial growth.

It is also relevant that the national universities are part of a unified national system, lacking the autonomy with which liberal opinion would endow them. Students are admitted on the strength of their performance in the school-leaving examinations, and the power of the universities to impose further selective tests is limited. (But several universities have been seeking to do just that in the admission season now under way, provoking fierce protests.) And the most sought-after degrees are those whose award is validated nationally, on the basis of an approved curriculum and examination.

Against that background, this is where the problems lie:

■ **Universities.** That the universities are in danger of being overwhelmed by their students is generally acknowledged. Wedded to open access by the memory of the troubles of 1968, the government is making a virtue of necessity (see page 133). One danger is that only the most ingenious and tenacious students will acquire a good education in the circumstances that now obtain. Another is that the assumption that research and scholarship are a crucial part of academic work will become even more of a dead letter than it is already.

The government acknowledges that there are problems, and is doing what it can to solve them (see page 134). Principles of good management would dictate

that there should be a greater devolution of autonomy to the universities; whether the device of the four-year contract between the education ministry and individual universities will have that effect will, in the end, depend on whether the government can sweeten its contracts with extra money.

Meanwhile, the plan to provide extra research funds to academics through the agency of a committee located administratively within the ministry of education seems an invitation to nepotism and soft judgement which have given French universities a bad name in the past. If the universities are to win genuine autonomy (a necessary condition if they are to ease the centre's financial burden by attracting funds from regional governments), then *France will need its own version of a national grant-making body distinct both from the ministry of education and from established organizations such as CNRS.* Why not begin now, before the suspicion becomes entrenched that the ministry of national education, reconciled to a measure of university autonomy, is planning to control them in the long term by research grants?

■ **Student support.** The legend of impoverished students eking out life in Paris garrets is too affectionately regarded to be exorcised quickly, but French inhumanity towards graduate students needs to be abated, especially now that the ministry of national education has acknowledged that it will not be able to teach students in future decades without more university teachers qualified at the PhD level.

The standard route to academic life is through the qualification of the one-year DEA (Diplôme d'Etudes Approfondies), involving (for researchers) laboratory work. Student support through this period, after a first degree, is hazardous enough, but university DEA committees, usually organized on a disciplinary basis, become the means by which students are chosen to receive grants to continue with a PhD course.

The numbers of grants seem invariably less than the justifiable demand. Often there will be two or three grants to distribute among 30 reasonably qualified students. Those who administer the system are humiliated that they rarely know in advance how many there will be. They and laboratory directors are embarrassed that so many disappointed students embark on research degrees in great hardship. *If the government wants more "docteurs", why does it not ameliorate the hardships of those who would meet its needs?*

■ **Mobility and employment.** One complaint is that researchers, both established

people and graduate students, are much less mobile than is good for the French research enterprise. Another is that France lacks a system of postdoctoral fellowships for keeping new PhDs at work while they cut their professional teeth and decide, if successful, what fields they will follow. A third is that scientists joining the research organizations are underpaid, and have to wait too long for promotion.

All three problems are linked, and require a common solution. The habit of immobility is engendered by the system requiring that students seeking a research degree must first acquire a DEA qualification, which entails close relationships with research laboratories at which, as likely as not, success will bring them their first research job.

The lack of postdoctoral fellowships *for French researchers within France* means that the transfer of new techniques from one place to another is impeded, while able and established people cannot quickly acquire the help they need to exploit new ideas. (With a few exceptions, even the most influential research groups in France are much smaller than their opposite numbers elsewhere.)

The solution is so obvious as to be breathtaking. *Why not convert established posts in the research organizations such as CNRS into three-year postdoctoral fellowships tenable wherever in France the holder chooses?*

The result would be that able people would get their first taste of independent research at the laboratories that seem to suit them best, that successful research groups would be better able to recruit the help needed to exploit new opportunities and that successful university researchers would be put on a more equal footing with those at the public laboratories.

This is the simplest change of the system there could be. People already on the first rung of the ladder of public service research would not be displaced or otherwise inconvenienced. There would be no significant extra cost — it would be necessary to endow host laboratories with research expenses, but they arise now when new people start work at the laboratories. And it would be possible for promising research groups successful in the competition for people to become competitively strong in a reasonably short time. One of the glaring defects of the present system is that the best groups are consistently understaffed and overworked.

The management of the public laboratories would no doubt be discommoded by a failure to recruit sufficient postdoctoral help to keep their programmes running, but the other side of that coin is that they would be better able to tell who should afterwards be taken on permanently.

■ **Bureaucracy.** The temptation to suppose that a national government

modelled by Napoleon is rife with bureaucracy should be resisted. In reality, the government is both accessible and informal. Ministers consult interested parties, and seem to take good advice wherever they can find it. And while the law is the law, most regulations are decrees, which can be relatively easily amended.

It is nevertheless irksome, and a considerable impediment to the welfare of the research enterprise, that questions of money and of the appointment of people should habitually require reference to the centre. That people should have to travel to Paris to intercede with officials over the rejection of applications for small amounts of money is similarly humiliating and a waste of time whose value is now appreciated in France more acutely than ever. *Now that devolution is under way (see page 131) cannot the Paris lawyers find a legal mechanism for behaving as if the government's researchers were honest people?*

There is a particular problem over the acquisition of special skills, computer programming for example. Few such people will work in government research because they can do much better elsewhere, but laboratories cannot employ them even on short-term contracts for fear of creating illicit government positions.

POLITICS AND SCIENCE

Chevènement's legacy to the 90s

Was Jean-Pierre Chevènement the cause of the transformation of French science in the past decade, or was he himself the product of a process already under way?

The question is still much debated, for which reason it is important that the tense in which it is asked should not be taken as a sign that Chevènement belongs to history or, worse, is dead. As minister of defence in the French government, he spent several days of last month on an aircraft carrier in the Atlantic. One day last week, with three other ministers, he was present at a passing-out parade at the national police college.

Yet there has never been a period in the recent history of the administration of French science quite like the year beginning with François Mitterrand's election as president on 10 May 1981. During the election, the Socialists had made no secret of their ambitions for research, but the reality of Chevènement's plans for increased spending were nevertheless a surprise for many people. The research budget for 1982 turned out to be 25 per cent greater than that for 1981.

This daring leap forward had been planned in advance by a working group under the chairmanship of Professor François Gros of the Pasteur Institute. Mitterrand spelled out his policy for research at a meeting at the Luxembourg

And there is not enough money to purchase all the software needed from outside contractors, so that far too many researchers double up as their own programmers. *Even in France, there should be a solution.*

■ **Money.** France compels admiration for the changes brought about in the past decade and more in the economy at large, not simply in research. It is now a much more prosperous country, even if there are constant envious looks across the border to the East — at West Germany. *Yet the government may have underestimated the true cost of its ambitions for research.*

The calculation is that no great harm may be done if salaries in the public service are so low that people can easily be tempted away to industry, but that will not be true for ever. Despite the success of schemes for adding to research spending from other sources, there is ample evidence that many able people could do much more were it not for the accentuating lack of operating costs. That, on balance, is not simply a waste of people but is potentially destructive of what must now be the most encouraging feature of French research — the generally growing general conviction that every able person can make his or her mark. □

palace on the eve of the election. In the international competition for discovery, will France be at the front or the back? We may be poor in natural resources, but we are rich in grey matter. That was the point at which Mitterrand promised that research and development expenditure would be increased to 2.5 per cent of the gross domestic product by 1985 — a promise subsequently written into law.

Chevènement's energy and enthusiasm seem to have been crucial. Gros has told how, soon after the election, he had visited Chevènement to explain that, whatever else was done, "the first essential is to change the relations between people" in research; his fear was that the imposition of new structures and tasks on a research community already disillusioned by neglect would bring further alienation. Why, he asked, not organize a great national colloquium at which these issues could be argued out?

The notion was not entirely novel; in 1956, the Mendes-France government had organized a colloquium at Caen. But neither Gros nor anybody else appears to have anticipated the energy that Chevènement would put into the project, which fitted with his own political position in a syndicalist faction of the Socialist Party.

Between October 1981 and the end of the year, no fewer than 31 three-day meet-

Colloquia galore

JEAN-Pierre Chevènement's most memorable achievement may have been his decision to hold a series of regional colloquia (*assizes*) at which members of the scientific community could voice their aspirations and discontents. Certainly, he has many imitators.

Beginning this year, the ministry of research and technology plans a series of such colloquia dealing with particular fields of research. The first of them, this January, launched "cogniscience" on the psychology and neurobiology communities. Earlier



Science minister in the early 80s, Jean-Pierre Chevènement.

this month at Strasbourg, there was a similar meeting on planet Earth.

The objectives are several — to improve coordination in continuing fields of study, to plan how to exploit emerging areas (order and chaos, for example) and to explore the relations between academic studies and their application.

But the Ministry of National Education has now joined in, with a colloquium at the Sorbonne last month which gave the minister, M. Lionel Jospin, the opportunity to repeat Allègre's slogan "Diversity means equality" (see page 133). □

ings were organised throughout France, culminating in a four-day meeting in Paris in mid-January 1982. It is estimated that some 25,000 people took part in the regional meetings.

The organization of this gigantic consultation was carried out by a committee under François Gros, with Dr Philippe Lazar (then the president of the scientific council of INSERM, now its director-general) as vice-president and rapporteur. Even now, Lazar vividly recalls how, after nearly a year's intensive work on the organization of the colloquia, he had been looking forward to a vacation. Instead, Chevènement asked him to move to INSERM right away.

Among others, one of the emergent themes was the importance of research as a means of bridging the economic gap between rich and poor countries, now embodied in the great emphasis in French research on the problems of tropical agriculture. But the overarching theme was that science belongs to the people and is a part of the general culture. □

The heat of competition

ONE should not forget that the republican spirit is alive and well in France, more than 200 years after the French Revolution. The grandest people are called "monsieur", as in "Monsieur le Président". And some of the grandest people every day shake hands with those who sit outside their doors, letting through those with appointments and diverting others elsewhere.

Another practical consequence is the institution of the *concours* — the system of competitive examinations by which people compete for places in the public service (which includes student places at the *grandes écoles*, whose *concours* are anonymous — see page 135) throughout France. The objective is to banish nepotism. One Briton working at an INSERM laboratory fulsomely admires the system, which he says should be adopted everywhere.

But there are obvious drawbacks for the management of laboratories. In CNRS, for example, the competition for places (held twice a year) means that particular laboratories cannot be sure that promising PhDs whom they would wish to fill particular slots will succeed in the national competition for places at the first, or second or even umpteenth attempt. Successful directors must have a supply of soft money (perhaps from industrial contracts) up their sleeves.

Promotion is also determined by *concours* — and the chance of success by the low ratio of vacancies to applicants. The obstacles to promotion to the status of *directeur de recherche* (group leader) is one of the chief discontents of young research workers in the public service.

The tendency towards centralism in France, everywhere apparent, also has other origins, mostly Napoleonic. The disadvantages of centralism have traditionally been freely acknowledged, but people have then shrugged their shoulders as if to say that little can be done about them. One of the achievements of the second Mitterrand presidency is that the cosy conventions of centralism are being eroded. The calculation seems to be that French economic growth will be faster if devolution gives regions an influence on their own welfare. That seems to be correct in the case of at least one region in the southwest (see page 131).

But decentralization is being worked out in a centralist fashion; there are the same rules for all the regions, while the devolution of responsibility for education, planning and economic development is far from complete. But in the long run, regional involvement in educational matters could be crucial for research. □

"We want to play the game"

DIRECTOR J. C. Duplessey at the CNRS Radioactive Tracer Laboratory (Institut des Faibles Radioactivités) tells how, when he published his first paper in an English-language US journal in 1971, his professor told him that he had been stupid. "Nobody will read it", he was told. But now the boot is on the other foot. "We want to play the game, and we have learned how to do it."

Where and how to publish is on everybody's mind, but there seems only one answer: in English, and in an international journal. The apparently serious suggestions of a few years ago that people's performance should be determined by a points system, with so many points for a paper in journal X, and so many fewer for a paper in journal Y, have mercifully now been dropped. But there is a general understanding that there is no general case for publishing in French in a French-language journal. Then you will not be read by the people you need to reach.

Nor will you be respected by your colleagues and compatriots. The annual reports of many public laboratories include not merely lists of the papers published during the past year, but an analysis of the proportion appearing in foreign-language journals (see, for example, the figure below).

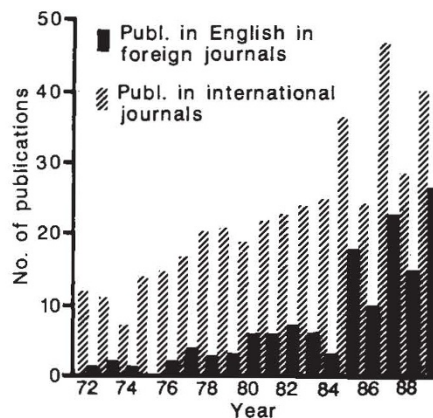
Yet as things are, the change of practice seems to have made little impact on the bibliometric statistics. Recently published figures suggest that between 1981 and 1986 inclusive, the French share of the world's literature fluctuated narrowly and, if anything, that it declined (Martin *et al. Science and Public Policy* 17, 14–26; February 1990). In 1981, the French share of publications in the US National Science Foundation's file of journals was 5.02 per cent, but had declined to 4.84 per cent in 1984, rising to 4.87 per cent in 1988. (The corresponding figures for the United Kingdom are 8.34 per cent, 8.16 per cent and 8.19 per cent.)

No doubt these figures should be regarded with caution. For one thing, they are inevitably out of date. For another, there is plenty of anecdotal evidence — references to outstanding French papers in well-known journals — to suggest that the benefits of the new attitude towards publication have not yet worked their way through. There is also some weight in the observation of one laboratory director that it was fruitless to go looking for evidence of a resurgence of French science "when we may simply have started publishing in English". But the habit has come to stay.

That the French reputation for chauvinism should be so directly belied is proof of a profound sea-change of opinion, linked with a general appreciation that

even the French government's generosity towards research will not enable France to make its own way in a competitive world without external collaboration. So people are also forever on the lookout for opportunities for collaboration, perhaps by the judicious placing of postdoctoral fellows in overseas laboratories, perhaps through collaborations with opposite numbers elsewhere and also through the European Communities.

But compliance does not mean pleasure. For one thing, there are practical difficulties. People whose mother-tongue is French do not write easily in English. (This may be one explanation for the good sprinkling of English-speakers, American or British, in the public labora-



tories.) More contentiously, it is also asserted that French is intrinsically more capable of clarity — which may be another way of saying the same thing.

In any case, most people seem to hold that while English is now the language in which they must write papers — as it has also become a passable lingua franca of conversation — it will be a matter of great regret if French is altogether abandoned. Philip Lazar, the reflective director-general of INSERM, says he hopes that "the time will never come when no science is written in French".

Nor need it. In contrast with those of the English-speaking world, French researchers still regard the production of books as an honourable occupation. Journals such as *La Recherche*, whose strong suit is high-level popularization, appear to be as much a pleasure to write for as they are to read. And the general popularity of technology as well as the need for interprofessional communication has been a powerful impetus for French technical publishing at all levels.

Yet the clinching sign that the use of English has come to stay must be that the *Comptes Rendus de l'Académie des Sciences* now precedes everything it publishes with an extended abstract in English. □

RESEARCH SPENDING

Whatever happened in 1986?

CAN YOU see politics in a graph? Yes, if it is a graph of French spending on civil research (see right) The 'accordion' effect, as the French say, of policy changes in 1986 and, then, 1988 cries out for explanation.

The present period is one of renewed growth after the cutbacks between 1986 and 1988, but the French research budget is only just finding a character of its own. State research spending, and how this is reflected at the laboratory bench, still bears the imprint of the exuberant policies of the young Socialist government elected in 1981 and then the sober pruning of a neo-Gaullist government that held office for two years from 1986.

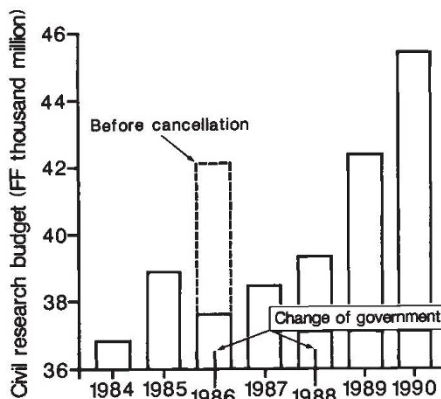
But the tone of the decade as a whole is undeniably that set by the Socialist government formed by the newly elected president, François Mitterrand. In 1981, his new Minister for Research and Industry, Jean-Pierre Chevènement, organized a series of now historic colloquia (*assizes*) to help determine the shape of research policy, spawning radical initiatives that found their way onto the statute book in the 15 July 1982 law on the orientation and programming of science and technology research.

The government declared that civil research spending should rise to 2.5 per cent of GDP (gross domestic product) by 1985. To that end, the 1982 statute committed the government to increase the civil research budget by a remarkable average of 17.8 per cent a year and to increase the number of state-supported researchers by 4.5 per cent each year until 1985.

In 1983, Hubert Curien, the present Minister for Research and Technology (see next page) took over from Chevènement, and innovative schemes were announced to encourage technological progress. A tax incentive scheme to

promote industrial research was set up with the goal that, by 1985, industry should contribute 1.5 per cent of GDP to research and development.

EUREKA, the now highly successful European Communities initiative to promote trans-frontier collaboration in high-



technology industry, was proposed in 1985 by Mitterrand, but it was Curien's brainchild.

It would be facile to say that this early period was uniquely good and that it came to a sudden stop when, in March 1986, the Socialists lost power. (Mitterrand remained as president, during an uneasy spell of what was called cohabitation.) But the neo-Gaullist government led by Jacques Chirac sought above all to curb public spending and to encourage the private sector to carry more of the burden of research support. The 1986 budget was annulled and the budgets of the large research organizations, such as CNRS and INSERM, virtually frozen.

Whatever the economic merits of the Chirac government's drive to streamline what it regarded as a costly and overweight public sector, those were lean

years for state-supported basic research. CNRS, long regarded as a hive of left-wing trade unionists which had become too large and too powerful, was at the centre of a maelstrom.

The ministries for research and for higher education were merged under Alain Devaquet who, with encouragement from conservatives inside and outside government, launched a plan to reform CNRS. But this failed, leaving the research council's affairs in turmoil for over a year.

Devaquet resigned and was replaced by Jacques Valade, but with a much-diminished ministry; most of the budget had been handed to the minister for industry. In the event, Valade achieved little; his appointment was followed by elections which, in 1988, brought the Socialists back to power, with Michel Rocard as Prime Minister and Hubert Curien once again in charge of research.

After a short period when higher education and research were lumped together, Curien was given his own ministry of research and technology from December 1988. The civil research budget, which groups together state finance from all ministries, was reinstated — and the Chirac government was accused of budgetary deception, using defence spending to mask a fall in civil funding.

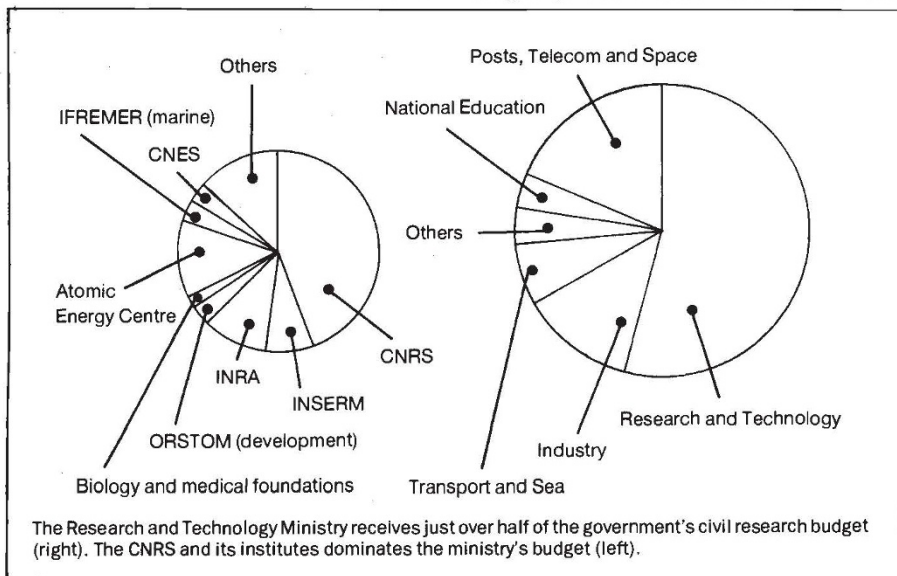
With Mitterrand once again declaring research and education national priorities, Curien was able to inject FF830 million into the research budget immediately to offset the cuts of his predecessor. The 1989 budget was up by 7.6 per cent, recruitment began again and, in the 1990 budget, salaries were improved.

But the growth in the public sector is more like half that of the pre-1985 period. Furthermore, Curien has made it clear that he wants to encourage both basic and applied research, but that big organizations such as the CNRS must run a tighter ship. A committee for evaluation has been set up and plans to 'modernize' the CNRS are under way.

At the research bench, all is not rosy. With inflation running at 3 per cent a year, the 7.3 per cent increase of the 1990 budget amounts to a more modest 4.3 per cent in real terms. The figure is even less when costly space and aeronautics, which were given a special boost, are subtracted. And, because the number of researchers has continued to rise throughout the decade, but faster than budget increases, the average scientist's research money buys almost 20 per cent less than ten years ago.

Yet the present government has not wavered in its objectives. It wants to make sure that France is well placed for the year 2000. And it now aims to see national civil research spending — hovering around 2.3 per cent of GDP — rise to 3 per cent.

Peter Coles



Curien weaves beguiling web

M. HUBERT Curien is an unassuming, almost shy, man with the qualities of a terrier. He was summoned from his post as director of the Centre Nationale d'Etudes Spatiales (CNES) to superintend French civil science on the break-up of Chevènement's ministry of industry and research in 1983. During the Chirac interlude (1986–88), he was elected president of the European Science Foundation, but then summoned back to Paris as minister of research and technology when the Socialist party was returned to power.

Curien believes that French science has, indeed, become stronger over the past decade, partly at least because of his government's willingness to spend money on research. But he insists that research had not been neglected in earlier decades. One subtle change, he believes, is that the French are now proud of their research institutions. In the old days, "we were proud of M. Pasteur, not of the Institut Pasteur."

Links between basic research and industry have also been strengthened, partly at least because of the government's willingness to support (through, for



Unassuming terrier Hubert Curien.

example, CNRS joint projects on a 50:50 basis. Curien is pleased with the way in which CNRS has functioned as a focus for these activities. The interaction has also encouraged French companies to spend more on applied research. "If we had not done this, we should have achieved nothing", Curien says.

Another striking feature of the past decade has been the steady internationalization of science — "it's now a real thing". He believes that French science has benefited powerfully from the impetus that has driven individuals into international collaborations.

He notes that French research groups profit greatly from the relatively small sums available from the European

Commission, whose spending on research has grown to 4 per cent of total European spending on research.

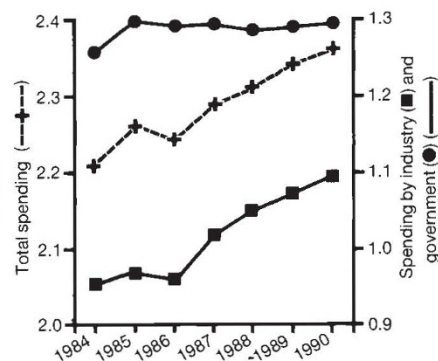
Curien also acknowledges that problems remain. One is mobility or, rather, the lack of it: people tend to stick in the same laboratory or other institution for too long. The concentration on Paris, around which something like a half of all French scientists work, is another.

But except for the salaries of beginning scientists at public laboratories, and the bottleneck in promotion in the middle ranks (which he is trying to widen), Curien is not too worried about the general unflattering comparison between salaries in the public laboratories and elsewhere. "If industry took more good people out of CNRS, I would be happy."

On the general opinion that France needs a substantial scheme of postdoctoral fellowships for its own nationals, he is ambivalent. He acknowledges that postdoctoral fellowships would encourage mobility within the network of government laboratories. Such positions would also help to improve teaching and research at the universities. But, like many others, he is impressed by the experience of 1969, when the then government agreed with the demands of trade unions that postdoctoral fellows of long-standing should be given permanent positions. "That", Curien says, "was a catastrophe."

Curien's position is powerful because his ministry is powerfully placed at the centre of the scheme of things. Other ministries (except defence) must say what they spend each year, and how. This enables him not merely to shape the general balance of research activity but also to back small-scale initiatives. A few months ago, for example, he was putting his weight behind a scheme due to Jean-Pierre Changeux, professor at the Institut Pasteur, for marrying French neurobiology with mathematical studies of the properties of neural networks; according to Changeux, he had mentioned the goal to Curien at a chance meeting. And about now, Curien will be giving a final opinion on an attempt to define French involvement in the Human Genome Project. (Many influential people are now less cool than previously.)

Others of Curien's schemes are less particular. Thus he began a programme (now costing more than FF1,000 million a year) enabling intending researchers, many of them industrial engineers, to write PhD theses by means of a three-cornered partnership with a public or university laboratory and a company. More recently, he has set up a national committee for the systematic evaluation of French science and technology, which



Figures (% GDP) reveal that industry takes the credit for much of the recent increase in spending on research.

in turn has spawned a small unit called l'Observatoire des Sciences et des Techniques, bent on the development of indices of performance.

Yet one of the ministry's goals remains beyond Curien's reach. It has long been the Socialist government's view that research spending should amount to 3 per cent of GDP, putting France on a par with West Germany, the United States and Japan. This year, the percentage is 2.38 per cent (see figure). The ministry blames the shortfall on France's industrial enterprises, whose spending on research has grown, but not as quickly as the government asks. But the figure shows that it is the government's spending that has stagnated, as a percentage of GDP, at just under 1.30 per cent.

But Curien's ministry does more than merely administer science and technology; it is one of the chief means of persuading France's taxpayers (other than those who get tax credits for research spending) that science and technology are good for them.



Pride of France: the Pasteur has at last ousted Pasteur in the scientific hierarchy.

Thus a recent popular (and handsome) booklet on French science under the title "A new impetus (*élan*) for research" echoes the president of France, François Mitterrand, by declaring that its goal is to "make research a national priority". Research, it declares, "is at the heart of the development of modern societies. . .". Research will enable France to "meet the challenges with which the national economy will be confronted in the global market" and to "keep its place among the principal industrial powers of the planet".

Nobody at the research ministry is shy of this rhetoric, which everybody believes.

EMPLOYMENT

Working on the public payroll

ONE way or another, most French researchers work for the government. There are more than 22,000 of them (and 37,000 support staff) on the payrolls of the research councils and the other public organizations active in civil research. (The Commissariat à l'Energie Atomique or CEA, for example, employs more than 1,400 people on research as well as 4,000 on research support.) The numbers of qualified scientists and engineers at the universities may be even greater.

For what it is worth, employment in the public service is growing overall. This year, the research ministry estimates that 432 new posts in research have been created (offset by the loss of 31 posts at the CEA). This amounts to a growth of research posts of 1.9 per cent. The growth of support staff between 1989 and 1990 was roughly half as much.

Luckily, the members of this small army of people do not all behave as civil servants. The republican spirit, as well as the common name *chercheur*, gives them independence. Many are prepared to bite the hand that ultimately feeds them.

Otherwise, industrial research and development is a growing source of employment, as are international organizations as different as the Institut Laue Langevin at Grenoble (see page 137) and the Joint European Torus (the European Commission's thermonuclear fusion laboratory) at Culham in Britain. One also senses among French researchers a growing interest in working at public research laboratories elsewhere in Europe; the Max-Planck institutes are most often mentioned.

In France itself, there is also a handful of institutions which, while largely supported by government funds, enjoy an exceptional degree of autonomy acquired either by tradition or by access to an independent source of funds. One obvious example is the Collège de France, created in 1530 by the then monarch François I to enable him to keep up with the scholarship

And, of course, there are many in research who hold that the grand phrases are merely a statement of the obvious. But the French research ministry differs from comparable organizations elsewhere in taking such a positive stand in favour of the ways in which it spends its budget funds. It is good for the morale of those who work in the ministry's dependent organizations, and may even have helped to cultivate the general French interest in all things new and technological. Curien, who is in no sense a salesman in the conventional mould, may have done more than he imagines to engender enthusiasm for French research. □

often "derisory") by part-time university teaching. The present salary structure in CNRS strongly emphasizes the importance of the promotion barriers in the determination of researchers' well-being.

So the research ministry had promised a three-year promotion plan that will loosen the structure. Beginning in 1991, those who have spent four years on the lowest rung of the research ladder (in the grade *chargé de recherche de deuxième classe*, or CR1), will be promoted to CR1 against evidence of their competence in research. The budget for the current year also allows for a shift in the balance between the three senior and two junior research grades, the effect of which will be to replace 462 CR2 research posts by a similar number in the senior grades (DR1, DR2 and DRE, where DR means "*directeur de recherche*" and E stands for "*exceptionnel*").

There are similar proposals for improving the promotion prospects of support staff, so that an extra FF120 million is spent on salaries this year. Yet the employment of support staff is a widespread headache for laboratory directors. Even secretarial jobs must be filled competitively, by *concours*. Technician-engineers are usually able to do better for themselves in commercial industry than in the public service. Computer experts are almost impossible to recruit on the salary scales on offer, with the consequence that many researchers are reconciled to writing their own computer programs (while others skew their industrial collaborations so as to get help of this kind). □

ORGANIZATIONS

Playing the name game

ACRONYMISM has become part of French culture, the influence of the Académie Française on the language notwithstanding. Prudent organizations publish lists showing what the acronymic names for their dependent units mean. What follows is a guide to the principal French research agencies and their dependent parts.

Organizations in France quickly acquire a life of their own. To create a new organization within the public service is no easy matter: the whole government has a say, and the Council of Ministers must approve. But once created, an organization cannot easily be dissolved. Both the bureaucracy and the unions will use their influence in the interests of permanence.

The Centre National de la Recherche Scientifique (CNRS), which celebrated its fiftieth anniversary last year, is the oldest and the largest. Its purpose is the conduct and encouragement of basic research in the whole of science. To that end, it employs 26,000 people, more than 11,000 of them researchers. Its public subvention in the current year is FF10,330 million, up 6.9 per cent from the previous year.

INSERM stands for Institut National de la Santé et de la Recherche Médicale and operates on a scale roughly one-sixth that of CNRS. The current budget (FF1,830 million, up 5.6 per cent from 1989) allows the employment of more than 1,900 researchers. Many of INSERM's research units are free-standing laboratories, more often (as at Lyon, for example) sited near hospital complexes than university student campuses. The interests of these two research councils deliberately overlap. CNRS takes the whole of research for its canvas, but there are several joint CNRS/INSERM research units.

INRA (for Institut National de la Recherche Agronomique) will cost the research ministry FF2,450 million this year (an increase of 5.0 per cent). Its operations are more self-contained than those of CNRS and INSERM, both of which are increasingly dependent for research funds on partnerships with other agencies and industrial organizations. Its 1,670 researchers are only one-sixth of its total manpower, reflecting INRA's role in providing agricultural extension services. □

Money oils the wheels

SINCE 1983, France has offered industrial and commercial enterprises an abatement of their tax bills on account of the research they carry out or otherwise support, but on a formula devised by Jean-Pierre Chevènement that must often seem a little like that of the mediaeval torture apparatus called the rack. The tax credit is calculated not on the basis of what enterprises spend in the relevant year, but on the extent to which their research spending has increased from one year to the next.

How well has the system worked? A study last year by two industrialists (Jean Cantacouzene, director of research at the oil-company Total, and Pascal Gendreau, joint director-general of the government organization for small and middle-sized business) has shown that the system at least provides a means by which the government can get to learn of the changing pattern of research in different kinds of industries.

One surprising finding is that tax credits tend to be a larger proportion of total research spending in traditional industries, such as furniture and textile manufacture and in food processing, than in high-technology industries, no doubt because the companies choosing to register for credits now have only recently embarked on such research.

The system is also cunningly biased against large enterprises. Of 346 companies with turnover exceeding FF500 million applying for tax credits in 1987, the credits eventually awarded amounted to

only 2.5 per cent of total research spending, compared with 12.8 per cent for the 3,682 companies with a turnover of less than FF500 million. It also seems that the smaller businesses constitute the fastest growing of the tax authorities' applicants, suggesting that the scheme serves its purpose of spreading the research culture.

The figures brought to light by the tax-credit scheme are part of the basis for the government's assertion that French industry is still spending less on research and development than it should be. The report of the Cantacouzene-Gendreau study concludes that industrial research is some 0.5 per cent of GDP less than it should be if France is to keep up with West Germany and Japan in relative terms. That deficit amounts to FF25,000 million a year at present.

Overall, the numbers of companies benefiting from the tax credit system multiplied fivefold between 1983 and 1989, to an estimated 7,000 (the returns are not yet complete). The cost to the Treasury is estimated to have been FF2,600 million last year — but the cost of administering the system is said to have been "derisory".

For the future, it seems to be agreed that the scheme should be given more publicity, and that the government should agree to make it permanent. Already it has been conceded that companies making substantial research expenditures in a single year should be able to spread the funds over several years. □

INDUSTRIAL RESEARCH

Can government back winners?

FRANCE has taken a long hard look at Japan's success, and wishes it could follow suit. But, with French industry not willing to shoulder the responsibility for spending what it might, the government has become the initiator of last resort.

That seems to be the philosophy on which the French government is now working, and the explanation for the substantial support for industrial research over the past two years. Between them, the research and the industry ministries will this year spend about FF5,000 million on industrial research of a general character, quite apart from the best part of FF6,000 million spent on research at the CEA and other mission-orientated research organizations concerned with space, aeronautics and the like. The largest single increase in the research ministry's budget for the present year — 30 per cent — takes its general fund for industrial research to FF1,565 million.

There have always been hankering in that direction. The legend of the French

nuclear energy industry began that way, with a deliberate decision to found a new industry with research and development. Did not France also invent EUREKA (in 1983) as a way of persuading other European states to invest funds in high technology?

Research minister Hubert Curien leaves no room for doubt that the sponsorship of industrial research is his priority for 1990, as it has been for the past two years. The emphasis will be on the search for new products and processes, to which the ministry expects to commit FF300 million this year, on perhaps 40 projects. The chosen fields are in new materials and food technology and biotechnology.

Two other goals have high priority, of which the more ambitious is that France should make a mark in the development of high-definition television (HDTV). It is only a small part of the calculation that France itself is likely to be a natural market for devices that bring the clarity of the cinema-screen into every living room.

More relevant to the choice of this priority is France's conception of itself as Europe's research strategist. There have been several occasions in the past 30 years when France has invested its own funds in huge technical projects it could not hope to carry through on its own, in competition with other players on the international markets, but which have been strategically important for Europe.

Nuclear energy is such a case. Although there has been a brief pause in French reactor construction (see page 139), if — some would say when — there should be a revival of demand for nuclear generating capacity in Europe, French nuclear contractors may be better placed than others to win orders from European utilities.

Much the same has happened in aeronautics and space launching, where French investment in research has been used (together with political persuasion) to prompt the formation of international companies that manufacture civil aircraft and offer space launching facilities (Airbus Industrie and Ariespace respectively). In each case, the objective has been to create a European counterpoise to a *de facto* US monopoly.

French support for HDTV is, rather, directed eastwards. From the outset of the EUREKA scheme, several projects have been directed at the processing of digital representations of video images, the basis of schemes for radically improving video definition. Non-French companies such as Siemens (West Germany) and Philips (Netherlands) have been closely involved from the beginning. But nobody should be surprised if official French enthusiasm for HDTV — the EUREKA rules allow governments to contribute towards companies' research expenses — culminates in a proposal for a joint European venture to head off the Sony's of this world.

The processing of silicon wafers is the research ministry's other immediate goal. The code-name is JESSI (for Joint European Submicron Silicon). The immediate goal is to make a 1-Gbyte memory chip, but the hidden agenda might be to make a *supercomputer* on a single chip. Modest Hubert Curien's ministry will acquire clout (perhaps even kudos) if the enterprise succeeds because of its ability (relative to that of comparable European ministries) to urge its client companies towards investment by offering (sometimes threatening) to spend its own money.

For the rest, the ministry plans to concentrate on small and middle-sized companies, traditionally cared for by a state agency called ANVAR (for Agence Nationale de Valorisation de la Recherche), whose budget has been increased by 10 per cent this year. It will be interesting to see, a year from now, how many of those intermediate companies are in the business of high technology. The guess of 100 per cent will not be far from the mark. □

To modernize and open up. . .

FRANÇOIS Kourilsky, the molecular biologist from Marseilles who is now director-general of CNRS, was appointed to his post by Hubert Curien in 1988 with firm instructions to "modernize and open up" CNRS. How well does he believe the task is going?

He is anxious that the organization should not be mistaken for the whole of French science, noting that it accounts for less than 19 per cent of the total civil budget. But he is pleased about the growing links with industry. At the latest count, industrial contracts with CNRS laboratories number 2,700, nearly two for each of the 1,300 distinct research units. Their total value is FF1,300 million, more than a tenth of the total budget. There is, he believes, a long way to go before the laboratories will be at a loss to know where next to sell their services.

Industrial contracts seem to serve a wider purpose than to keep the wolf from the door of some CNRS laboratories. To this outsider, one of the wider consequences has been to persuade industrial companies that there is, indeed, some benefit to be won from research and development.

Kourilsky says that, until recently, French industry has not significantly increased the numbers of people it employed on research and development. But now, he says, there is a surge in the recruitment of people, especially in fields such as mathematics, computer science, electronics and chemistry, not to mention molecular biology. Evidently he shares Curien's view that those who work for him should be doubly honoured if they leave to work in industry.

But is there a danger that the balance between contract work and basic research will be too much skewed against the latter? Not as things are, he holds. Perhaps the difficulties will arise when, as the volume of contract work continues to grow, but patchily, some laboratories will find themselves short of people for their core programmes while other, lacking contracts, will have people but only modest research funds.

Kourilsky agrees with Curien (see page 126) that the salaries of young researchers should be improved, but considers that the promotion bottlenecks are "still a problem".

On the scheme to provide university teachers with research funds through a committee within the education ministry, he holds that the source of funds should be independent of the university system. "On that, I diverge from Claude Allègre." The problem is that of evaluation. He regrets that the Napoleonic universities "lack independence".

CNRS differs from most comparable

organizations in the large number (1,300) of laboratories in which its people are dispersed. The range is from a handful of people to some scores. So how are new laboratories started, and old laboratories disbanded?

As always, it is easier to start than to stop. The process of evaluation, Kourilsky believes, is accurate and reliable. But the law requires that a decision either to open or close a laboratory should be taken only on the basis of expert advice. The process

BUDGET PRESSURE

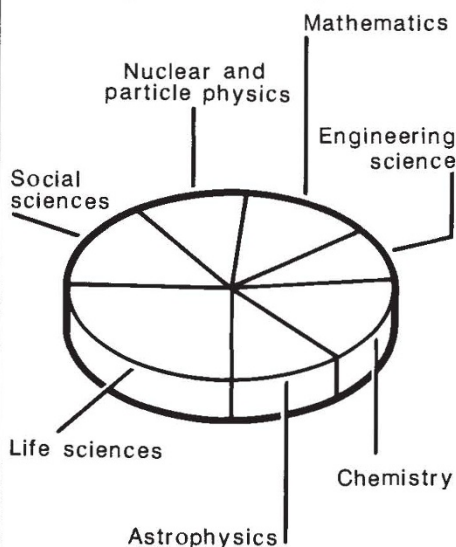
Staying ahead of the game

THE albatross around the neck of CNRS is the risk of being blamed for everything that goes wrong.

Although, on balance, CNRS attracts more praise than protest, the years ahead may be more difficult. The budget squeeze on CNRS's disposable expenditure is one source of strain. The need for some means of financing university research will be a further complication.

CNRS is potentially the more vulnerable because it has a finger in every pie. The existence of INSERM notwithstanding, for example, the life science division (one of seven) takes a quarter of the total budget. But CNRS is also strong in the humanities and social sciences. (The Science de l'Homme et de la Société division takes more than 10 per cent — see figure below.)

Over the decades since the early 1960s, when it was common to find CNRS researchers working in isolation, and on a shoestring, in cubby-hole laboratories throughout the University of Paris, the organization has shown itself to be remarkably resilient and adaptable.



Distribution of CNRS funds between divisions, 1990.

can be slow.

On the future of the organization, he believes that links with universities will be strengthened, together with those with industry. But there are particular opportunities, he believes, in the emerging pattern of a single Europe for forming stronger links with overseas laboratories.

Kourilsky has not been at his job for long enough for his impact on CNRS to have become clear. Moving the bureaucracy will not be a simple task. But he seems to have one important augury on his side — a largely enthusiastic research force. □

The Chevènement upheaval of the early 1980s may nevertheless be one of the best things to have happened to CNRS, confirming its central place in the French scheme of things as well as the role to which it had already aspired of being one of the chief means of research planning in France.

The then-new director-general of CNRS, Pierre Papon, made forward planning his centrepiece. After an elaborate consultation within CNRS and industry, a score (literally 20) research themes were singled out for special attention, and became the basis for research planning in succeeding years. While the interest of the particular themes may since have been attenuated, the mechanism remains. CNRS is forever organizing consultations among interested groups to determine what weight should be given to particular themes.

During the same period, the influence of CNRS on university research has been formalized and legitimized, by the device of associated (*associés*) laboratories, set up by means of formal contracts between universities and CNRS, and in which CNRS and university employees work side by side. (Other research organizations, such as INSERM and CEA, follow the same practice.) Between them, the research agencies have come to provide support — people as well as money — for most of the outstanding research at French universities. Throughout France, CNRS is this year supporting 1,003 research groups by this mechanism. (It also has 366 in-house research units, some of them very small.)

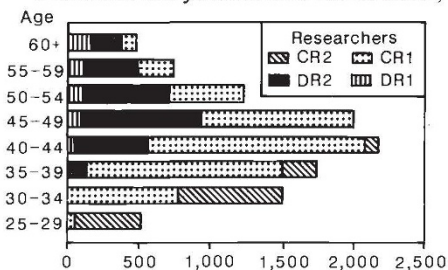
There is no shortage of academic research groups looking for support of this kind. By a curious device invented in 1982, the education ministry nominates (on the advice of CNRS) research groups considered deserving of outside support — *recommandé* is the designation — which may look for such crumbs as fall from the tables of CNRS and the other *grandes organismes* of research, perhaps

in the end for full support. On one reckoning, there are a further 1,000 of these research groups waiting in the wings.

Now, as always, the snag is the budget. Despite the general growth of funds for research, the CNRS share of the civil budget has not grown as quickly as the whole. And the commitment of nearly 75 per cent of CNRS's share to the salaries of its employees means that its disposable income is shrinking. On one estimate, annual research expenses at CNRS account for FF110,000 a researcher, compared with FF180,000 at INRA and FF215,000 at INSERM (the best heeled of the research-support organizations).

CNRS seems bent on righting that imbalance. University research groups, especially the *recommandés*, were chilled at the end of last year when Kourilsky (see previous page) remarked that "CNRS does not have the means to support all university research groups" even when they are excellent. That sharpens the dispute over the education ministry's plan to provide research funds direct, but it also requires that CNRS itself should choose between being the daring cat that steals the cream from the top of the milk and being the pillar of the establishment it has become used to being.

That is for the years ahead. Meanwhile,



Age-structure of CNRS research population, 1988.

CNRS has kept its options open. The organization is typified by its post-Second-World-War headquarters at Gif-sur-Yvette, in the suburbs southwest of Paris. The 'campus' is a park, acquired cheaply in a deal that requires CNRS to keep a team of gardeners on its books so as beautify the park. On one side is a fairly recent chateau (now a visitors' hostel) and, on the other, a collection of laboratories embodying the recent history of CNRS in bricks and concrete (mostly concrete from a less prosperous age). Despite the gardeners, the campus seems seedy.

What CNRS has been doing is plain enough: it has been following trends apparent elsewhere. Although nuclear and particle physics are still responsible for FF790 million, the proportion has fallen from 22 per cent in 1978 to 10.9 per cent in 1989. But life sciences, less than 18 per cent in 1978, are now 25.3 per cent (and employ more than 2,800 researchers at CNRS in-house and out-house units). Inevitably, the life sciences division of CNRS spends more of its budget on recur-

rent costs than on equipment and (less predictably) just about half of its total budget on associated and joint (with other councils) laboratories. In the first half of the 1980s, engineering sciences (especially computers) grew quickly — and the number of research posts virtually doubled — but now chemistry is the most quickly growing.

CNRS has also been ageing. In 1988,

RESEARCH CULTURE

A club-like atmosphere

THOSE who work for CNRS behave like members of a club because they are members of a club. To be a CNRS researcher is to be a member of a distinctive group, as if it were to be the French Navy or the *corps diplomatique*. But CNRS is, of course, not quite as grand.

The sense of club is easily explained: for at least the past decade, entrants to CNRS have won their places in the public service by competition in the common *concours*. They vividly appreciate the distinction between themselves (who are in) and those who are out. At least until recently, they could be reasonably sure that they would work permanently in this branch of the public service, with occasional postings elsewhere.

But this commonality does not engender a dull sense of uniformity. Different research laboratories have their own distinctive spirit. Some are plainly riding high, perhaps sustained by industrial contracts or grants for special projects. Others harbour a deep sense of neglect. They are inevitably the laboratories most oppressed by the bureaucracy of their parent, which is organized into seven divisions and no fewer than 36 sections, each with its own secretariat.

The underlying difficulty is the small proportion of the CNRS budget free for research expenses. More than 75 per cent of the budget is committed in advance to salaries; heat, light and maintenance take a substantial proportion of the rest. (INSERM seems better placed in this regard.)

Travel funds are not too hard to come by; most people acknowledge they can make one substantial overseas journey every year or two, while European Communities sources are increasingly used for travel within Europe. But the proportion of a laboratory's total budget remaining in a director's hands for research expenses may be relatively very small, perhaps less than 10 per cent of his salary bill.

Yet CNRS abounds with people who hold the highest opinions of their organization. For many, the sense of security and freedom they enjoy makes up for the gap between government and industrial salaries. One, the director of a laboratory

only 35 per cent of its researchers were younger than 40. Although the recruitment and promotion rates are now to be increased, it is difficult to see them quickly creating the bottom-heavy pyramidal age-structure one would expect to find in a research organization. No wonder that Curien (see page 126) says that he is glad that industry threatens to hire away senior people. □

at Gif-sur-Yvette, says that CNRS provides unique opportunities for research. Another gives it as his opinion that CNRS, whatever its faults, has become the dominant arbiter of quality in French science. The organization's willingness to enter into collaborations with universities and industrial companies, sometimes taking the initiative in forming them, is generally commended.

One British member of a joint CNRS/INSERM laboratory says that he is more settled, and more productive, in France than he had been at a British university. He reckons that the continuing shortage of academic positions in Britain must soon stimulate a southwards stampede across the English Channel when British people realize that, at the outset, all the French they need is that required to keep body and soul together.

Another Briton at another laboratory, fresh from a postdoctoral position in the United States and with an enviable reputation for the development of a new technique, says that he chose the CNRS laboratory from among half a dozen at which he had been offered a position. (Sybaritic considerations seem to have played a part in the decision.) Testimonials of this kind abound. Because, to paraphrase *Anna Karenina*, contented employees are all alike, but discontented employees differ in their discontent. The following complaints against the organization are necessarily more voluminous. Their balance should not be judged by the space they occupy.

First, there are problems about people. Laboratories not well-endowed with outside funds are less able than others to keep competent young people at work while they compete for permanent places at successive *concours* for permanent positions. The result, some say, is that able people are often lost to the system at the beginning of their careers.

Filling vacancies is a constant headache. If a vacancy should arise, even among the technical or administrative staff, it cannot automatically be filled. Instead, the section or even division to which the laboratory belongs will at least consider whether the vacancy should instead be awarded to some other unit. According to

at least one director, there are no mechanisms for appointing even junior staff on a temporary basis; either a public servant, or nothing.

There are recurring problems about research allocations. Laboratory chiefs are usually told, in the February of the year to which the information applies, what their allocation of funds will be. One CNRS director says that last year, after his budget had been cut by 30 per cent with no explanation, it took him until November to get the cut restored. (Luckily, the rules do not require that funds should be fully spent in the year for which they are intended.)

The need to make visits to Paris regularly, either as a member of an advisory committee (which is essential for staying in the swim) or to lobby against some particular injustice, is particularly irksome for those who live and work elsewhere. Reimbursement for the cost of doing so, as for other expenses legiti-

PLANT SCIENCE

mately incurred on CNRS business, is generally agreed to take months. One researcher says that he expects that CNRS will at any stage owe him FF20,000, or a month's salary.

Although many CNRS laboratories on university campuses enjoy the respect of and a good deal of influence with the associated universities, others lead a precarious existence there. One such group has been required to move its laboratory several times in the past seven years to suit the convenience of the university, and is now threatened with another move in October.

The most serious of the complaints against CNRS is that at least some laboratories appear to be inadequately informed of the overall policies that determine their affairs. This seems a shame when the people concerned are every bit as full of enthusiasm for their work as the general run of people working in CNRS laboratories. □

Hungarian sowing seeds

THE Institut des Sciences Végétales at Gif-sur-Yvette differs from others in the park in that it is brand new and that its director, Adam Kondorosi, is newly arrived, with his wife and co-worker, from Hungary.

The refurbished laboratory is that previously occupied by the teams who danced attendance on Gif's giant phytotrons, which were in the 1960s proof of CNRS's promise to botanists that they are deserving of large equipment as are nuclear physicists. The phytotrons have now been dismantled and the laboratory disbanded.

Kondorosi has been commuting between Gif and Szeged in Hungary for the past 18 months, while recruiting people for the laboratory. His appearance, more or less permanently, in this Paris suburb justifies earlier fears in Hungary that liberalization would entail the loss of able people (see *Nature* 344, 611; 12 April 1990).

Kondorosi says that he is enjoying himself enormously, but that whether he will stay for good depends as much on his wife's inclinations as his own. Meanwhile, he says that he has continuing responsibilities at Szeged, mostly for the continuation of his research with graduate students, so that he will have to make occasional visits. CNRS seems compliant.

For the rest, Kondorosi's tale is an illustration of how CNRS (in this case with some help from INRA) sets about founding a new institute. The impetus was the conviction that the molecular and cell biology of plants would have important applications in agriculture. An international committee spent some months head-hunting for a director until it found

Kondorosi (he rattles off the names of those who turned down the job). Now the objective is to recruit a team of people, perhaps internationally, to staff the five research groups whose work will stamp the laboratory's programme (and whose heads are already in place). The hope is to build up to between 60 and 80 people in four years.

One distinctive feature of the programme is that external collaboration is to be built in from the outset. Kondorosi says there are already agreements with the Max-Planck Institute at Köln and the department of molecular biology at Rome, not to mention his old institute in Hungary. He is also planning to work closely with the complementary CNRS institute at Toulouse, and is hoping for further support from the European Communities and from the European Molecular Biology Organization.

Kondorosi's own field is the study of how the symbiosis of rhizobia and plant roots is reflected in and mediated by the reciprocal exchange of chemical signals between them, which is one leg of the institute's programme. Another group will aim at similar understanding by more classical studies of the hairy-root syndrome (a variant of crown gall disease). There are also groups concerned with plant cell signalling (by means of auxin), the mechanism of damage by plant viruses and the molecular genetics of *Arabidopsis* — the eukaryotic plant with the smallest genome so far recognized.

Like other up-and-coming CNRS laboratories, the new plant sciences institute is already embarking on graduate education. Five or six students seeking the

Regional consuls in the wings

MME Katherine Piquet-Gauthier is the new regional delegate of CNRS at Montpellier, with responsibility for CNRS affairs in Languedoc-Roussillon in the south-west of France. She is one of a dozen people appointed last May, under the terms of a decree promulgated by CNRS last December, to offer regional groupings of laboratories with a more immediate presence than Paris can provide. But it is not yet clear how far administrative devolution will go.

The twelve regions and the sites of CNRS's regional offices are Alsace (Strasbourg), Aquitaine and Poitou-Charentes (Bordeaux), Brittany and Loire (Rennes), Limousin (Orleans), Ile de France (see below), Languedoc-Roussillon (Montpellier), Lorraine-Ardennes (Nancy), Midi-Pyrénées (Toulouse), Normandy (Caen), Provence-Côte d'Azur (Marseille) and Rhône-Alpes (Lyon). The administrative centre for the Pas de Calais region had not last month been chosen.

Many of the regional directors have not yet taken up their posts. The arrangements for the Ile de France (greater Paris) are complicated by the great concentration of CNRS responsibilities in the region, with the result that there will be five sub-regional directors working through a central office. Similarly, there will be two sub-offices in the Rhône-Alpes region catering separately for Lyon and Grenoble.

What will the regional offices and their directors be able to accomplish? Laboratory directors and researchers have a variety of aspirations for the new arrangements. Those who labour under a sense of neglect hope the new arrangements will give them a stronger voice in Paris. More immediately, there is also the prospect that the regional offices will simplify the bureaucratic structure (although some fear that their influence may be in the other direction).

On the question of whether devolution will make it easier to pay people's legitimate travelling expenses more quickly, Mme Piquet-Gauthier says "not yet, but wait and see what it's like when you're here next". □

DEA diploma (a pre-PhD qualification — see page 122) have already been accepted for next year. Kondorosi expects that university relations will be simplified because two of his group leaders are also university professors.

But will there be enough teachers for them? Kondorosi says he has already advertised 18 vacant positions at the institute. There can hardly be a quicker way for someone from Eastern Europe to learn the ways of the competitive West than he has chosen. □

CNRS reflects with pleasure

CNRS, which is always evaluating other people, has recently been evaluating itself. But the result is not so much a critical appraisal of the largest single research programme in France, as a kind of guidebook to science in general. The report of the evaluation is dominated by the theme of the growth of interdisciplinary research requiring multidisciplinary teams.

The self-evaluation, the report of which has just been published as *Rapport de Conjoncture*, has been prepared by 22 commissions established to evaluate themes singled out by CNRS for study, and ranging from Earth and Solar System to order and chaos and the transformation of societies. Readers must be prepared to look between the lines for outright self-criticism.

But one general theme is the emergence of a number of interdisciplinary problems to which French science should pay attention. One singled out for discussion is that of global change, but the study also notes that the properties of neurons promise to be of great importance in computer sciences as well as in physics and mathematics.

This colours the report's opinion of present arrangements for the training and recruitment of young people into science. It argues that there is a need to improve and increase the training of doctoral students to ensure a sufficient supply of researchers and university teachers. But doctoral training should also prepare young researchers for working alongside people of other disciplines. The report asks that something should be done to improve the public image of certain disciplines, citing mathematics (surprisingly) and chemistry as being unpopular.

On interdisciplinary research, most conspicuously at present represented in

CNRS by four named research programmes (in materials science, energy, environment and technology at the workplace), the evaluation draws attention to some of the problems faced by those engaged on them, in particular by the risk that work on interdisciplinary problems may complicate the two-year evaluation of their research achievements by one or other of the 49 subcommissions, are responsible for this work. The report argues that people's willingness to work on interdisciplinary projects should be regarded, *a priori*, as favourable for their careers.

Of the international connections of French research, the evaluation acknowledges that English has now become the language of communication in international science, but says that there remains room for French on the national scene and in relations with francophone countries.

In general, the evaluation says, it has taken an optimistic view of the place of French science on the international stage, but it acknowledges that there may be a bias in the process of evaluation — research that is inherently good will be well spoken of, while that which is bad will leave little impression on outside critics.

The document acknowledges frankly that international collaboration entails the risk that researchers will be lost to France by means of a "brain drain" which is not confined to France. But it says that French collaboration in large international projects has an effect "at once dynamic and stabilizing". It says that the involvement of French researchers in overseas laboratories, and visits of overseas researchers to France, but particularly the exchange of scientists within Europe, "must be one of the keys to our successful development".

Living better by one's wits

THE Napoleonic centre, it appears, can be flexible enough when there is cash to be saved. That seems to be why every laboratory in the public service seems to have a freebooter's licence to strike a deal on research with some third party, within the limits of a framework agreement. So laboratory directors at CNRS and others of *grandes organismes* have become entrepreneurs of a kind.

The results have often been spectacular. In some CNRS divisions, external support may be as much as a third of the total. Other ministries and public agencies provide more than half of this extra money, for projects as different as the provision of special research equipment and for research projects with a bearing on some development by a still nationalized

industry — the High-Speed Train, for example. But particle and nuclear physics and the life sciences are almost exclusively financed out of CNRS funds.

It is also striking that France derives a substantial research support from international sources — in 1987, this amounted to 17.9 per cent of CNRS's disposable income, exactly the value of research contracts with industry. The European Community is a particularly important source of funds, both because participation in the major European research programmes carries public researchers into joint projects with industrial researchers and because the much smaller sums available for occasional travel from Community sources valuably supplement what CNRS can spend. □

Some rights and wrongs

AMONG the points made in CNRS's evaluation of itself are the following:

French groups have played an important part in the development of **particle detectors** at CERN and DESY since the success with Gargamelle in 1973, but steps should be taken to build on the experience of constructing the LEP injector at Orsay. Building a **4 GeV** electron accelerator, "no doubt in a European context", would allow important work with high-energy photons in **nuclear physics**. New instruments, in Hawaii and Chile will be followed by the Very Large Telescope (four linked 8-metre telescopes) being built by the European Southern Observatory, but French **astronomy** should be primarily concerned with the supply of theoreticians.

More generally, the subcommission on these topics expressed concern at the difficulty of preparing graduate students both theoretically and with a capacity to tackle unknown problems, with the "linear" careers of young researchers and with the continuing shortage of research funds.

The mathematics evaluation says the French **mathematics** school is "probably one of the best in the world" (which, by general consent, is fair). There are up to 2,500 mathematicians at universities, with only a tenth as many at CNRS. Now, the evaluation says, CNRS should be employing more mathematicians who are, it is said, less and less easily classified as "pure" and "applied". By way of proof, the evaluation draws attention to the invention, by engineer Jean Morlet, of the concept of wavelets (*ondelettes*, or convolutions of periodic and gaussian function as sets of elementary functions in which seismic signals can be expressed.)

Surface research is crucial in, for example, the electronics industry, and "France is now well-placed" by the provision of national facilities by collaboration between government agencies and industry. But the advantage could be in hazard because of the shortage of CNRS funds for medium sized equipment, while the immobility of people makes the development of effective research groups difficult.

In *informatique*, France is said to be strongest on the theoretical side and in the development of languages, while Japanese and US industrial laboratories dominate such fields as the development of an **optical computer**. Yet in both respects, the evaluation says that European collaborative programmes have a crucial role. CNRS is said not to have increased its numbers of specialists in these fields sufficiently. □

A search for *égalité* in diversity

CLAUDE Allègre, the bluntly spoken geophysicist who was director of the Institut du Physique du Globe at Paris VI until two years ago, could make his name with the quiet revolution in higher education on which he is now engaged. Or he could lose his academic friends.

Allègre, energetic and at once ambitious and impatient, has become director of higher education at the Ministère de l'Éducation Nationale (and de la Jeunesse at des Sports). But he keeps his hand in at the institute. He teaches a course and spends time in the laboratory. He hopes to manage every weekday morning next year. But even now he is working like a dog.

The task is herculean. By any standards, the university programme is calculated to astonish. In the academic year just ending, there have been 1.13 million students (or their equivalents as part-timers) at France's 76 universities, which means that 40 per cent of school-leavers at least begin on higher education. Allègre says that the ratio should be 60 per cent. "Then we shall be like the United States and Japan."

There is another driving force. The



Down to Earth: Allègre is keeping one foot in the university world.

university system is what it is because of the student rebellion in the streets of Paris in the spring of 1968. Nobody forgets that the Left Bank was occupied by students for days on end. (Many of those same students are now, no doubt, civil servants.) Thus has been accepted the principle of open access: qualify in *le bac*, the popular name for the *baccalauréat*, the nationally standardized school-leaving examination, and there will be a place for you at a university. Naturally, the numbers grow.

So, inevitably, does the budget. In real terms (francs of constant value), spending

on higher education has increased by 35 per cent since 1980, but half that increase has been squeezed into the past two years. The French government will have spent FF27,500 million (in present money) on higher education in the current year. Next year (the budget is just now being devised) it will no doubt spend more.

Allègre is not one to be dismayed by the immensity of his responsibility. He spells out the agenda. Build more universities (eight are planned, four in the greater Paris region called the Ile de France, four at places yet to be determined). Lift the spirits and the public reputation of academics by increasing the pay of able people, perhaps by 25 per cent. Recruit more graduate students, perhaps by offering them better stipends. Improve the quality of academic research by a system of competitive research grants administered by the ministry. Sign contracts with universities so that they can spend their budgets to the best advantage.

There are even plans to change *le bac*. Allègre is proud of a scheme to introduce students to chemistry by asking them to build molecular models; by the time they come to grapple with the laws of multiple proportions and the like, they will at least know what is meant by valency. There are also plans to introduce continuous assessment of students' performance in the awarding of *le bac*, if not in mathematics, then in other fields.

All this is meant to happen quietly. "We are making a revolution", but we say that "nothing much is happening". The more natural course would have been a "big new law", but that tendency is the "French disease", Allègre says.

Allègre does not hide from difficulties, but meets them head-on. Will not a system in which universities' activities are predetermined by a contract with the ministry mean that university freedom is curtailed even more than at present? On the contrary, says Allègre. Universities knowing what they want to do can negotiate an appropriate contract with the ministry, and then be more free than ever to pursue their goals.

He is passionate on this point, complaining that his republican compatriots have consistently failed to appreciate that diversity means *égalité*, and is not antithetical to it. The tendency has been to suppose that *égalité* requires that everybody should follow the same curriculum at the same kind of school. Emphasizing that the participation rate should be high (60 per cent) he says, "Look here, France is a Catholic country, and Jacobin and Napoleonic. . . in the end, the Catholic influence has won through."

Those are the forces in favour of uniformity and centralism. He acknowledges

A new vision or an old mirage?

ACADEMICS in France differ in their estimates of whether the government's new promises of support will materialize, but only because there are different degrees of scepticism. Most say, "We have heard all this before. We'll wait and see what happens." Many others will not wait.

What follows is honest reporting of academics' views adapted so as to conceal its sources, for reasons that should be obvious. (It matters less that academics are literally civil servants than that their senior colleagues can still powerfully influence their academic prospects.)

One group of 40 university teachers in literature — a group now responsible for the first-year education of 700 students — is asked (by the university administration) to take responsibility for 1,200 students. That would mean increasing the student to staff ratio from 20:1 to 30:1. There would be no extra teachers.

A teaching group of similar size, most of whose members applied for special contracts on the grounds of special expertise in teaching or research, has found that only two special contracts have so far been awarded. The recipients are both in their fifties, and are people of acknowledged distinction. One is so eccentric that he no longer teaches, and does not publish either.

There is a general complaint at the teaching loads of university professors; ten hours a week of lectures is commonplace. "That's impossible", says one professor at Paris VI. Such a load means that even the teaching must be skimmed, while there is literally no time for research — and the funds for supporting research are steadily declining.

The position may be "even worse in Britain, but not in West Germany — there they seem to be spending money more intelligently". In France, there is a crisis. There are "not enough teachers, and those there are thinking of leaving", mostly for international organizations and industrial laboratories.

Other academics protest that the criteria for deciding promotion within the system are far from objective. A proposal that people's competence as researchers should be judged objectively, perhaps by publications records, was rejected by the ministry a year ago. □

that universities as they are are too much alike. But freely negotiated contracts with the ministry could give universities the right and the opportunity to be different. The first negotiations with universities, in the west and south of France, are now under way within the framework of an elaborate set of parameters conjured by the ministry — 12 m² of space for a science

student, for example, but 3.5 m² for one in law. Individual universities are making special claims in respect of extra things they do.

The contracts, when negotiated, will run for four years which, a little to Allègre's delight, breaks the rule that ministries must not anticipate spending not yet voted by the National Assembly. (One guesses that the ministry's lawyers will deal easily with that subtlety.)

Allègre also agrees that French universities have been too conservative. Scornfully, he notes that molecular biology was taught at and by the Institut Pasteur long before it found its way into the curricula of the universities in Paris and that plate tectonics (his own field) remained in limbo for too long.

The ministry's mechanism for supporting university research is more controversial. Academics from all over France will compete for a share of a pot of money administered by a ministry committee, half of whose members are drawn from European countries other than France. Allègre is fighting for a 15 per cent increase of the funds available in the budget for 1991, now being drafted.

Might not a ministry committee assessing the quality of research proposals be tempted to use the funds at its disposal for solving other than research problems? Would not an independent grant-making

agency be safer? Allègre does not agree. For one thing, the committee is international, but its subcommittees will also rely on CNRS assessments when making their decisions.

As proof that the system is working, Allègre notes that it has already drawn blood. "A lot of people are very upset — mediocre people and some universities." But he does not like the US system of competition for research grants; "indirect costs" are "ridiculous", as is the difficulty of finding support for long-term projects.

He is confident that "zero — nought" will be spent on "big programmes". But he would like to encourage research in innovative fields. He rattles off a string of topics — *informatique* in clinical medicine, molecular identification by physical means, cogniscience (the new name for neurobiology), the geophysics of the topmost 100 metres of the Earth's crust and the meteorology of cities.

So why, with these grand plans, does Allègre risk losing friends? Few will dispute the good sense of his ambitions. One worry is that the interventionist habits of the ministry will persist. More important (see below), there is a general fear that the funds for supporting Allègre's quiet revolution will be, as so often in the past, inadequate for the need and, perhaps, even hijacked by the pressing needs for general support in the university system. □

UNIVERSITY REFORM

On the way to open access

In the academic year just ending, there were 1.13 million students at French universities, an increase of 77,000 over last year. Next year, there will be more — just how many more will be known only when high-school students have been told the results of *le bac* this year.

For several years, the system has been growing at about 8 per cent a year. The mounting pressure of numbers is felt even in the highest reaches of the government — the official communiqué from the Council of Ministers (the French government's cabinet) announced that the building of 200,000 m² of extra space at universities had been sanctioned against the new academic year.

Since 1960, when there were a mere 215,000 students, the scale of French higher education has multiplied more than five times. The growth has been most rapid in the humanities, whose students account for more than a third of the total. Law and the *sciences économiques* (which include accountancy and management) account for more than 250,000 students. But in 1989 there were 192,000 students following courses in science and engineering, an increase of nearly a half since 1980.

As Mr Kingsley Amis would have predicted had he been French, more has

meant worse. Faculties have not grown as quickly as student populations, so that ratios of teachers to students have generally declined. Harassed teachers at institutions other than the *grandes écoles* have been forced to skimp on research and scholarship as teaching and administrative burdens have increased. Who can wonder that many researchers in dedicated research laboratories scorn their nearest-neighbour academic colleagues? Or that, mostly for lack of suitable candidates, there were 2,000 vacant teaching posts in June 1988?

The pressure of numbers is greatest in the early years. Undergraduates follow a three-stage curriculum (the *premier*, *deuxième* and *troisième cycles*). The attrition rate at the end of the first cycle (for many, the end of the first year of studies) is high. For those who stay the course, the *troisième cycle* or fifth year is either a vocational course (such as the preparation for a career in teaching) or, in science fields, a preparation for research.

The education ministry is not for nothing the Ministry of National Education. It operates schemes for the national validation of degrees, the *licence* and *maître* qualifications of the first and second cycles in particular. Those with

academic bent follow a course leading to a DEA (see page 122) qualification, previously a sufficient qualification for higher education work, possibly following that by embarking on a PhD thesis, lasting for two or three years.

The government's plan to put right this state of affairs rests on these components: **Salaries and careers.** Teaching posts will ordinarily be filled only by people with PhD degrees. Teaching salaries will be tied to those in the public service and a system has been instituted by means of which the salaries of academics with special responsibility and competence in research, teaching or administration may be augmented if those concerned are offered special contracts of employment by the education ministry. The ministry says it has received 15,000 applications for such contracts, the effect of which will be to increase the salary of a beginning academic from FF8,000 a month to FF13,000. Allègre (see page 133) reckons that the average uplift of salaries will be 25 per cent.

As part of the process of deliberately preparing people for careers as academics, the ministry has set up thirteen *centres d'initiation à l'enseignement supérieur* at which, it is expected, graduate students seeking careers at universities will attend for one week twice a year during the average three-year duration of a PhD course. Graduate students selected for these programmes will be paid extra (a total of FF9,200 a month), but will be expected to teach classes (usually in the *premier cycle*) and to hold small-group seminars while preparing their theses. The plan is to increase the 3,000 people at present following this programme to a total of 6,000 (implying an annual production of 2,000 academics in all fields); graduates of the *grandes écoles* will be extra.

New universities. Existing universities earn intangible credit at the Ministère National de l'Éducation by their willingness to fall in with the notion of expansion, but there are limits to what can be accomplished on existing sites. Montpellier (see page 138), with 50,000 students, is pondering whether it could take an extra 20,000; one solution would be to spin off first-year teaching to Nîmes, 60 km away. Nîmes, with ambitions to be a university-city in its own right, is not so sure.

So France, almost alone among industrialized countries, is embarked on creating eight new universities — four in Paris and four elsewhere. The new Parisian universities, which will be multidisciplinary, will be suburban universities — at Cergy-Pointoise, Versailles and Mame la Vallée et Evry with a dependent campus at Melun-Senart. But it is also planned to increase by rebuilding the capacity of the Sorbonne and other universities in central Paris.

The hope is that the four new provincial

universities, the locations of which have not yet been chosen, are meant partly to meet the demand for higher education which is, even at present, unsatisfied in west and central France. (There is at present a net movement of students towards Paris, the southwest and the Lyon region.) The problem will be to persuade able academics to move away from the centre.

Research. The government acknowledges the need to "arrest the slow erosion of university research over the past several years". The ministry of education hopes to accomplish this by several means.

There will be a system of competitive grants for research and scholarship administered by a committee (the Conseil Scientifique de l'Education Nationale) under the Nobel prizewinning chemist Jean-Marie Lehn. Salary supplements for academic-researchers should work towards the same end.

It may also help that the government plans to encourage the emergence of new university centres of excellence. It has nominated a handful of places which, "by the quality of their research, the diversity of their teaching and the attractiveness of their locations", may rival "Oxford, Heidelberg and Berkeley" in the united Europe of 1993. The ministry has so far nominated Grenoble, Strasbourg, Orsay-Polytechnique (southwest of Paris) and Toulouse; it promises further names — but a few of them — before 1993.

Organization. The ministry of education, at the Napoleonic hub of France, is used to redefining and rebalancing the interests of the centre and periphery. The new calculation is that four-year renegotiable contracts with the ministry of education will give universities an incentive to skimp on spending in fields in which costs are elastic, and to invest the funds they save where there are intellectual opportunities, or students to be recruited. The council of ministers, on the recommendation of the ministry, will continue to appoint the rectors of the universities.

Several innovations are promised. A study is under way (with the ministry of economics and finance) to see whether budgetary procedures can be radically simplified and whether real-time ("en temps réel") techniques of data processing can assist the administration of universities. (Ways of counting students would be a big help.)

Cosmetics. The ministry, which hopes that it will be possible to double the number of doctoral students preparing theses in the five years ahead, plans to set up an organization for monitoring all theses under preparation. It is hoped that this information (to be published annually) will form the basis for determining university research policy as well as for comparisons between French and other research. □

Lyon's hot-house university

WHY should French teenagers compete so fiercely to go to universities that are unable, by their constitution, to award degrees? Because the universities are not universities at all, but *grandes écoles*.

These citadels of French higher education owe their existence to functional considerations: how best can the state secure the services of able people who have been specially trained in certain fields? By recruiting them young and competitively, by making them civil servants for at least ten years and then, by training them. This was the *École Polytechnique* Napoleon's device for assuring a supply of artillery officers.

By definition, the *grandes écoles* are in Paris, or at least they were. But in the 1980s the ministry of education embarked on an experiment to see whether they could be transplanted to provincial soil. Now, after more than a decade of heart-searching and hard work, a version of the *École Normale Supérieure* has been transplanted from Saint Cloud, in Paris, to a complex of post-Modern buildings on the site of an old abattoir in this provincial city, now the next largest after Marseille.

The *École Normale Supérieure* de Lyon has taken in 100 students in each of the past two years. They are a cut from those successful in the national *concours*. Most give themselves an extra two years preparation after *le bac* before entering the competition, which means that *normaliens* are usually 20 years old when they begin their studies. Although most of those entering the annual competition give one of the Parisian schools as their first choice, they (and their teachers) know they come from the top 0.1 per cent of whatever proxy for the national IQ distribution is measured by the *concours*.

Polytechnic Institutes

THREE relatively new institutions, in many ways intermediate in character between the *grandes écoles* and the national universities, have a particular influence. The best known is the Institut National Polytechnique de Grenoble, with roughly 3,000 students and an associated group of *grandes écoles* specializing in technical fields. There is also an Institut National Polytechnique at Toulouse and another in Lorraine.

All three were founded in the early 1970s as a means of stiffening higher technical education and lending coherence to its academic procedures. All are relatively small in terms of student numbers — between them the institutes have about 8,000 students. □

Moving the school from Saint Cloud to Lyon has not been trouble-free. The idea seems first to have been mooted in the mid-1970s, and more or less agreed by the arrival of the Socialist government in 1981. At that stage, those threatened with banishment from Paris, and their unions, pleaded with the new government to put a stop to the plan. But the then minister of education, having brooded for some time, decided not merely that the move should go ahead, but that Lyon's floor-area should be increased by 11,000 m² to a total of 36,000 m².

Guy Aubert, appointed director of the new school two years ago, is an energetic man; among other things, he reckons to travel 50,000 km a year on the autoroute between his laboratory at Grenoble and the school at Lyon. He has high ambitions, not least that of making Lyon the best of this esoteric bunch, as follows:

■ **To get the best students.** Even at the top, competition remains fierce. Lyon has to stake its claim on the affections of the brightest few hundred making their way to the *grandes écoles* by the reputation it establishes in the next few years. The counter-attractions of Paris will persist. But even as things are, 3,000 people compete for the 100 places at Lyon. Competence in some foreign language is required. French entrants are paid as junior civil servants.

■ **Education through research.** Lyon offers three options — mathematics and *informatique*, science of matter (physics or chemistry) and life and Earth science. From the outset, students at Lyon will be plunged into research (and, during the first two years, taught to write and speak English). The requirements vary from one department to another, but most students spend half of the first three years of the four-year course on laboratory work and research. In the process of doing so, they normally acquire (from the University of Lyon) a first degree and, usually, the *diplôme d'études approfondies* (a necessary but not sufficient qualification for teaching at a university). Students at Lyon follow as a matter of course the laboratory-based *magistère* curriculum. They spend the last of their four years either preparing for a two- or three-year PhD course or in qualifying as fully fledged teachers in higher education (the process known as *Agrégation*. Aubert expects that 9 out of 10 will head towards a PhD.

■ **Internationalization.** Like everybody else in France, Aubert is scheming to do his bit for the integration of Europe. One possibility is to recruit students from elsewhere to Lyon, perhaps as many as 50 each year. (The statutes allow foreign students to attend, and to pay no tuition fees, but they would not be paid or other-

wise dealt with as if they were French civil servants.) News of this scheme advertised on Lyon's research network apparently brought 18 university people from elsewhere in the European Communities and the European Free Trade Area to an enthusiastic meeting on 7 June. Further developments are awaited.

■ **Liberalization.** To guard against the danger that the *normaliens* will be over-narrowly educated, there is a scheme to mix students from the University of Lyon in with them. But there are no plans to follow, for example, the Massachusetts Institute of Technology in introducing liberal studies of some kind to the curriculum.

■ **Research.** In the long run, the success of the Ecole Normale Supérieure de Lyon will hang on the reputation it acquires in research. There are almost 150 researchers already at work, two-thirds of them on the payrolls of either CNRS or INSERM. It is a guiding principle that there should be strong links between the school and the national research organization, with the result that two of the university's six laboratories are joint CNRS-Lyon institutes while the others are less formally linked to CNRS. Aubert is entirely content to think of using laboratories at Grenoble as well as Lyon both as research partners for Lyon's academics and as places at which the *école's* students can follow their *magistère* programmes.

Much thought seems to have gone into the formulation of research programmes which, while having roots in traditional research, are conceptually innovative. For example, the people in *informatique* are concerned with the logic of parallel computers, the physics department with instabilities and order-disorder transitions in liquids.

So has the move indeed confirmed that it is possible to live, and to remain intellectually alive, outside Paris? Almost all the academics at Lyon have moved from Paris, although not from the old campus at Saint Cloud. Interestingly, three people (for this purpose a random sample in that their qualifications were that they speak English) had all used the opportunity of the move to Lyon to change the emphasis of their research. One common goal seems to be the creation of a distinctive line of enquiry, capable of catching national and international attention.

Those who have made the move are youngish people (and Aubert is proud of the average age of the faculty at Lyon). The reason is straightforward: as one explained, "the older people would not move". But even some of those who have done so acknowledge that there are ways in which "Paris is better". What they mean is that the extramural aspects of life in Lyon are not as varied as in the capital. That is perhaps something else on which Aubert should be working. □

What's in a number?

TELL the average academic in Chicago, Manchester, Tokyo (and probably anywhere else outside France) that you teach at the University of Paris and he is likely to say "Ah!, the Sorbonne", perhaps adding that it is "the oldest university in the world, isn't it?". In fact, the Sorbonne ceased to exist in 1790 and was given to the University of Paris in 1808.

In troubled 1968, that was divided into 13 campuses or, more precisely, what is now the Académie de Paris comprises 13 universities — each one numbered. But the numbers have verbal equivalents. A researcher in physics might, for example, give his address as "Paris XI", but say he works at "Orsay". And the rector would call himself "*Professeur en Sorbonne*", not at Université de Paris I.

The confusion is even greater than it first appears. While three campuses might still call themselves "the Sorbonne", being on the original campus in the Latin Quarter, Paris I is known as "Tolbiac", Paris III as "Censier" and only Paris IV, the old faculty of letters and arts, still calls itself "Sorbonne". Meanwhile, the Université Pierre et Marie Curie is always known as Paris VI, while Paris VIII, set up as an experimental university after May 1968, is called "Vincennes", after its original location in the eastern suburbs, but is now at St Denis in the north.

Foreign academics would, however, be right in thinking that the University of Paris is, with Bologna, older than other European universities. It began as a theological school attached to the cathedral of Notre Dame. As the number of tutors

MAGISTERES

Gaining distinction by degrees

IF universities can do little to select the students they teach, they can at least seek to distinguish between those who leave with degrees. That is one function of the *magistère* programme, originally conceived by Jean-Pierre Chevènement in the early 1980s as a way of redressing the balance between the *grandes écoles* and the regular universities.

The result is a highly selective beefed-up diploma for university students called the *magistère*. First introduced in 1985 in 70 selected university departments, in a wide range of disciplines, the *magistère* is meant to prepare students for research or industrial careers no less promising than those of engineers from the *grandes écoles*.

Students enter the *magistère* after the first cycle (first two years) of university education, but must have a special mention

in their diploma (DEUG). Because the *magistère* degree is not national, but awarded by the university, students almost always carry on their regular studies.

The Sorbonne appeared in 1253, as a theological school founded by Robert de

PARIS UNIVERSITY BY NUMBERS

Paris I	Pantheon-Sorbonne	"Tolbiac"
Paris II	(economic law, social sciences)	"Assas"
Paris III	Sorbonne Nouvelle	"Censier"
Paris IV	Sorbonne	—
Paris V	Rene Descartes	—
Paris VI	Pierre et Marie Curie	—
Paris VII	—	"Jussieu"
Paris VIII	Vincennes at Saint-Denis	—
Paris IX	Dauphine	—
Paris X	Nanterre	—
Paris XI	Paris-Sud	"Orsay"
Paris XII	Paris Val de Marne	"Creteil"
Paris XIII	—	"Villetaneuse"

Sorbon, and had a stormy history. It was opposed to the establishment of Jesuit orders in France and sided with the English against Joan of Arc. The Sorbonne was closed by Convention in 1790.

Once integrated into the University of Paris, the "Sorbonne" refused to accept the teaching of new disciplines. Consequently, new universities were founded to teach sciences, humanities and the social sciences. Only after 1968 did universities throughout France become truly multi-disciplinary. Today, in the first major reforms since the 1970s, eight new universities are planned, four in the Paris area.

With the growth of the university system as a whole, the numbers game has spread. In Montpellier, for example, there are "Montpellier I", "II" and "III", the first (teaching arts, literature and the humanities) also known as "Université de Paul Valéry".

Peter Coles

in their diploma (DEUG). Because the *magistère* degree is not national, but awarded by the university, students almost always carry on their regular studies.

In the first year, students carry out supervised research at a state laboratory, one half day each week. In the second, they are working full-time in a research laboratory and, in France, are given priority for grants under the European Commission's Erasmus and Comett programmes to study abroad. Students from the Joseph Fourier University at Lyon last year went to the University of Sussex and others to Philips in Eindhoven, for example.

The ministry of education has no plans to expand the scheme at present; much will no doubt depend on an evaluation of the scheme completed by Dr Guy Aubert.

Peter Coles

GRENOBLE

Disassembling Alpine science city

If France were the Soviet Union, this Alpine city would be named Akademgorodok and everybody would be a little self-conscious about its strategic and economic importance. But the city's ambitions seem to lie somewhere between an upmarket ski resort and a smaller version of Paris (to which every provincial city aspires).

As if in that cause, the mayor of Grenoble, M. Carrignon, has in the past few weeks put the city on the national political map by advising members of the Republican (centrist) party to which he belongs to vote Socialist in the local elections so as to defeat the candidates of the extreme-right National Front. For his pains, Carrignon has been suspended from party membership.

But the nature of the place is apparent from the autoroute from Lyon, just over 100 km away. First, there are traditional conveyor belts carrying limestone from a scar on a miniature alp to the east to the cement factories in the valley of the Isère, then the unmistakable outline of a particle accelerator taking shape at about the point at which the exit signs read "*Polygone scientifique*". The circular hole is, of course, the European Synchrotron, the 6 GeV electron synchrotron designed to be a purpose-built source of X-rays and γ -rays when it is commissioned in 1993.

Grenoble has grown to be the place it is by a sequence of accidents, among which the first was its choice as the site for the basic research laboratory of the Commissariat à l'Énergie Atomique (CEA). Another influence is more personal — that of Dr Louis Néel, who was still a member of the physics department at the University of Grenoble when he won a Nobel Prize (in 1970) for the discovery of antiferromagnetism. Néel laid the foundations for tempting to Grenoble the half a dozen CNRS laboratories, mostly centred on condensed-matter physics, that constitute the Polygone.

What more natural than that the city should also be the site of the thermal nuclear reactor which, under the name of Institut Laue-Langevin (ILL) is one of Europe's most prolific sources of thermal neutrons, used mostly for structural studies? The institute is jointly financed by France and West Germany, with smaller contributions from other members of the collaboration. Tucked away in the same *polygone* is a Max-Planck Institute of solid state physics, visible proof of West German commitment to the place.

Guessing at the numbers of scientific and technical people is more difficult at Grenoble than at, say, Novosibirsk, but CNRS is thought to employ about 700 qualified scientists here, CEA perhaps twice as many, while the less permanent populations of ILL and, eventually, of the

European synchrotron laboratory, may account for a further 1,000. Then there is the university. Allowing for technicians and administrative people, direct employment in Grenoble's public laboratories is probably not far short of 15,000, a substantial proportion of the regional population, estimated at about 400,000.

But that, people are quick to say, overlooks the uncounted scientists and engineers working for the small technical enterprises that have sprung up (with the encouragement of the local authorities) at Grenoble, originally as suppliers of goods and services to the public laboratories, but which have now cultivated national and international ambitions. (The continuation of the autoroute from Lyon is plainly marked "Turin", but francophone Switzerland is even closer.)

Grenoble, in other words, is a living proof that life outside Paris is possible, and can even be rewarding. One benefit has been that the laboratory-based culture has been able to forge a strong relationship with the University of Grenoble, to their mutual benefit. CNRS laboratories regularly have academics among their staff members, while researchers teach courses at the university. (The incentive is not monetary, but the simple consideration that teaching experience counts as a plus when promotions are considered within CNRS.) Similarly, academics and people from the various laboratories sit on each others' assessment, promotion and strategic committees.

The academic links with research are plain to see. At the CNRS Laboratoire d'Études des Propriétés Electroniques des Solides, graduate students (from other universities as well as Grenoble) outnumber fully fledged researchers (a third of whom are Grenoble academics).

This fruitful symbiosis rests in part on bread-and-butter considerations: academics have access to more sophisticated equipment than university laboratories can usually provide, while laboratories can profit from the flexibility of the funds provided by the university towards the overhead costs of their academics' and their students' research costs.

But there is more to say than that. Dr Guy Aubert, head of the CNRS Service National des Champs Intenses until two years ago says that, in the physical sciences, CNRS offers the only mechanism in France by which the quality of the research people do can be sympathetically and objectively assessed. To link a university with the CNRS system provides it with a yardstick for the measurement of self-improvement and the means thereto.

It goes without saying that the symbiosis provides the laboratories with recruits who can hit the grounds running. Gre-

noble is both the originator and an enthusiastic exponent of the *magistère* programme (see opposite) by which students are introduced to research while still working for their first degrees, partly by being taught by researchers and partly by working in research laboratories or at computer consoles. The *polygone* has provided a sparkling new building in which to house the *magistère* students.

There is a general lesson to be learned from all this: CNRS laboratories can profoundly influence a nearby university. It is not just that CNRS laboratories can provide neighbouring academics with facilities for research that would otherwise be lacking (thereby making the universities attractive to potential teachers), but that they can also hope to mould both the university curriculum and the composition of its faculty.

But the symbiosis requires readiness on both sides. Other CNRS laboratories complain that they must take in graduate students from neighbouring universities over whose curriculum they have had virtually no influence. *Formation*, the academics say, "that's our responsibility". Then the symbiosis cannot work. Nor can it when there is no CNRS or INSERM laboratory within reasonable range.

It is no wonder that Grenoble (with Strasbourg, Orsay and Toulouse) has been singled out as one of the outstanding university centres in France. In reality, there are both the Polytechnic University, with 2,000 students, and the three campuses of the University of Grenoble dealing (by numbers) with science and technology (the Joseph Fourier University), with social sciences and with arts and literature. The city has a student population of 30,000.

Not everything in Grenoble is lovely. The worry about salaries, generally through CNRS, quickly bubbles to the surface. Working researchers say that industrial salaries are generally 50 per cent higher than their own. Most people acknowledge that it is worth paying something for the extra freedom and interest that their laboratories allow. But 50 per cent? Guy Aubert says that even laboratory chiefs are now regularly head-hunted — most expect to get one reasonable offer a year.

Promotion is also a constant worry. Becoming a *directeur de recherche* (a salary grade), requires not just a *concours*, but passing through the eye of a needle which appears ever to shrink in aperture.

Some at Grenoble are also alarmed at the shrinking proportion of CNRS's income available for the direct support of research. This relatively well-heeled group of laboratories is well placed to secure outside contracts, and does well, but is alarmed that external dependence may eventually threaten what it considers to be its core research. □

A European Los Angeles?

MONTPELLIER has all the makings of Los Angeles, but it has a long way to go. For the time being, it differs by a fragment of a substantial mediaeval city wall, the like of which has never been seen in California, while it is still possible to look at clear blue sky. But not for long, if the fastest-growing city in France can keep up the momentum, it may soon have enough road vehicles to generate a pall of smog.

Montpellier also has the distinction of beginning as a university town. There are 200,000 permanent residents, but 50,000 university students who come and go.

Apart from the abundant youthfulness, the city has gone in for three contrasting and inconsistent architectural gimmicks whose like cannot easily be seen elsewhere. First, the old centre of the city has been covered with a sheet of terrazzo as vast as St Peter's Square, from whose edges protrude the upper floors of modern buildings, most of them apparently triangular, which are founded on solid earth. (The centrepiece of the display is a theatre, the Comédie, in which few plays play.)

Second, there is a gigantic air-conditioned bunker a good 300 m long in a distant corner, said to have cost more than \$2,000 million to build. It is a conference centre of the most modern kind, which provides the city with a car park and which is inhabited by the chamber of commerce and industry.

Third, there is the new home of the Conseil Général, the provincial government, constructed to a kind of athenian plan; there are half a dozen post-modern replicas of the portico of the Parthenon (with office suites behind) arranged in a semicircle and separated by a highway and an artificial river from the central office block, in glass and soft brown stone rising to a dozen stories. One Montpellier driver thinks the river a huge joke: "it would take a long time to get to the sea that way".

What is happening is that Montpellier believes it has a chance to become the most important city in the arc of the Mediterranean between Gibraltar and Marseilles. One piquant feature of the development is that the Socialist mayor of the city, Georges Frèche, and the Republican administration of the region, have sunk their political differences in this common cause.

Professor Roger Brunet, a geographer who is the director of the CNRS-financed "public interest group" RECLUS based at Montpellier, explains that there is a "launch-window" within which the city must somehow make its mark. ("RECLUS" stands for Réseau d'Etude des Changements dans les Localisations et des Unités Spatiales.)

The window opened in 1988, when the

national government devolved to the departments certain responsibilities for education, planning and industrial development, and when Spain and Portugal joined the European Communities, enlarging the city's vision to the West. But growth had begun before that, in 1965, when IBM chose Montpellier for a manufacturing plant (now the chief source of employment after the three universities). Legend has it that somebody at IBM drew a line from the company's research laboratory at Nice to its import base at Bordeaux, and found Montpellier roughly half-way between.

With that beginning, Montpellier's ambition is to become a technopolis — one blessed with sun and sea (5 km to the south, past the airport and through a group of small factories). There are also the Cevennes mountains 10 km to the north. The other assets are the universities and the large group of research council laboratories (INRA is especially well established) scattered about the city. The city is also the main base of CIRAD, with responsibility for the cooperative development of tropical agriculture. The city and

NUMERACY

Industrial mathematics booms

INDUSTRY seems to have taken to the heavy-duty computer and the techniques of model-building with the enthusiasm with which the French public has embraced Minitel — the ubiquitous domestic videotext service originally devised as an electronic telephone directory, but now used for gathering general information, train times for example. The result is that industrial researchers have set out deliberately to recruit mathematicians to their cause.

The impetus is twofold. Simulation is often much cheaper and quicker than experimental investigation, vividly apparent in the use of simulation by aeroengine manufacturers in the design of turbine blades (whence, in part, the present concentration of interest in fluid dynamics). The recognition of that truth is not unique to France. But what may be is the recognition by French industry that mathematics is one of the country's strongest suits, and that mathematicians are not always as unwilling to bother with practical problems as their reputation suggests.

But how to capture that resource? Elf's Solaize laboratory believes it has found an effective way of doing this, on behalf of the company's research effort as a whole. J-P. Valentin is a regular mathematician on the laboratory's full-time payroll who is not merely allowed, but required, to spend half his time on academic work.

the region are setting out deliberately to exploit these assets, seeking to attract small and large enterprises in agriculture, pharmaceuticals and *informatique* to science parks physically designed to be contiguous with the laboratories in related fields.

Brunet, whose unit has general interests (it is using its expertise in cartography to compile an atlas of the world as well as of France, and has advanced the doctrine of territoriality as central to the present development of Europe) is a bystander, but an interested one. One of his projects is the conceptual design of a highway from Gibraltar to Constantinople, on which Montpellier would be a crucial staging-post.

So when will the launch-window close? Montpellier seems realistically to appreciate that the world has become competitive. Toulouse, the centre of the aerospace and much of the electronics industry, is just 100 km to the northwest. More irritating, Nîmes, 50 km in the other direction, and best known for its splendid Roman amphitheatre, is nursing ambitions to expand (as, indeed, it is). The window will close only if the plans now hatched fail to materialize. Nobody in Montpellier believes that will happen. □

For the rest, Valentin's job is a mix of persuading researchers in the company's laboratories that many of their problems are often essentially mathematical problems and then of recruiting appropriate outside consultants who can help to solve them. He says that he would be unable to perform the second role if he were not himself a practising mathematician, able to mix with others on equal terms at conferences.

He describes the first function as if it were a kind of psychoanalysis. Most researchers, unaware of recent advances in mathematics, are slow and even unwilling to acknowledge that their problems may be mathematical in character. People used to making measurements with an experimental rig prefer to stick with what they know. He also claims to be a kind of midwife, recognizing that one research group may already have a solution to another's problem.

Valentin cites as an important technique in his business the organization of regular meetings at which Elf-sponsored PhD students (there are 120 of them scattered about the universities) present accounts of their research in the presence of their academic supervisors. These serve, he says, not just as ways of recruiting consultants, but as a powerful means of deepening the company's corporate culture of mathematics. □

NUCLEAR ENERGY

Reactors hit financial trouble

FRANCE'S ambitious nuclear programme has wound up in a curious dispute over the ownership of the chief reactor-builder, Framatome, in whose shares its chief rival, the Compagnie Générale d'Electricité (CGE) has acquired a controlling stake. The government is in a quandary over whether to renationalize Framatome.

This is an unexpected but unavoidable outcome of the past two decades, during which France has striven to make its nuclear energy industry second only to that of the United States. But now, with a slump in oil prices and a worldwide wariness after the Chernobyl accident, it has found itself with knowhow nobody wants and more electricity than it needs.

The 53 reactors belonging to the nationalized EDF (Electricité de France) — mostly of the pressurized water type, but including one fast-breeder reactor — supply 75 per cent of the country's 342,000 million kilowatt-hours of electricity production. With very few coal, gas and oil resources, France began strengthening its nuclear capability during the 1970s oil crisis. Successive governments continued the expansion policy, supported by a generally enthusiastic public.

France also has stakes in all aspects of the generation cycle. Cogéma, the industrial subsidiary of the Commissariat à l'Énergie Atomique (CEA), the state research agency, has almost cornered the world market in irradiated fuel reprocessing at its La Hague plant on the coast of Normandy, on the English Channel, with a capacity intended to be 1,600 tonnes a year by 1992 and as much as 40,000 tonnes by 2000.

Just as France's own construction programme matured, the Chernobyl accident led other countries to freeze their construction programmes, leaving France's two major manufacturers of nuclear technology, Framatome and CGE, with little hope of critical export orders. The situation was made worse by a saturated home market. In the 1980s, ten new reactors were commissioned to meet an expected demand that never materialized. And a new generation of fast-breeder reactors was planned to follow the experimental 1,200 MW Superphénix plant at Creys-Malville on the Swiss border. But soaring costs, unreliability, cheap uranium and national overproduction led this programme to be shelved.

To add to the slump in enthusiasm for nuclear reactor construction, doubts have now been raised about the safety of existing reactors. Earlier this year, it was revealed that the wrong bolts had been used in maintenance on safety valves at the Gravelines site on the English Channel coast near the Belgian border. A report commissioned by EDF revealed

similar incidents elsewhere and that the risk of a major accident in the next 20 years at one of the French reactors could be much higher than previous estimates. There are six 1,300 MW reactors on the Gravelines site; even the remote threat of an accident has made France's neighbours twitchy.

But the need to replace old reactors, combined with expectations that industrial growth will increase energy demand in the next decade, means that the reactor construction programme is not dead. Only last week, EDF promised that a new 1,400 MW reactor at Civaux would get the go-ahead next year after long delays.

The prospect of renewed growth has put Framatome and CGE at the heart of a political storm. Last month, CGE bought out shares in Framatome held by Dumez, giving it a 52 per cent of the company, a controlling stake. The government feels uncomfortable with its 45 per cent minority share (35 per cent CEA and 10 per cent EDF) and is now wondering whether to intervene by nationalizing Framatome again, so as to gain control over little-valued but potentially critical expertise.

CGE, privatized in 1987, is against such a move and, in any case, nationalization is likely to run up against a ruling of the present government guaranteeing neither privatizations nor nationalizations of industries in the current mandate.

Peter Coles

INDUSTRIAL RESEARCH

Getting back to business

CRUDE oil refiners in France have been driven into a corner — and into research — by the nuclear energy industry, and by the collapse in the market for heating oil. Elf-Aquitaine, which operates three refineries in France, says that the annual throughput of crude has fallen from 100 million tonnes a year to only 80 million tonnes, and demand for heating oil has fallen even more drastically.

The problem is how to win a greater yield of saleable products, notably petrol (gasoline, otherwise *essence*) by the intelligent cracking of crude. The company claims to be a pioneer in the automatic control of refinery operations. Now, at its research laboratory at Solaize, south of Lyon, it has a team of eight people perfecting the operating parameters of catalytic petroleum crackers, believing that understanding will lead to a greater yield of lighter fractions.

The research programme has been a joint effort by Elf and CNRS since 1956. A group of four CNRS researchers have been seconded to the Elf laboratory. When their project finishes two years

Science parks multiply

RESEARCH may not immediately make nations prosperous, but it can do wonders for the prosperity of cities. That seems to be the principle on which several municipal governments are now working, from Lille and Rennes in the north and Lyon in the centre to Montpellier in the southwest.

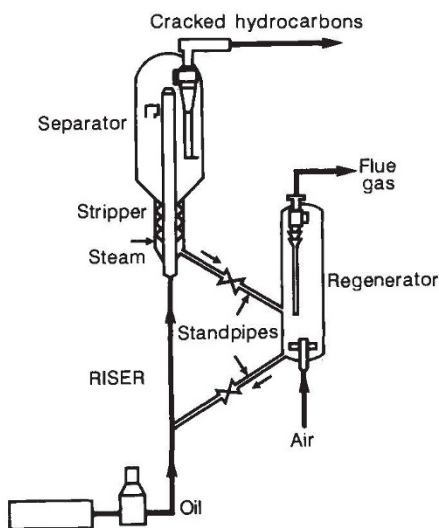
So science parks are multiplying. At Montpellier, there are no fewer than three, conceptually centred on the city's intellectual assets.

The presence of IBM has stimulated the city, in the 1980s, to persuade small companies in *informatique*, robotics and artificial intelligence to what it calls its Parc du Millénaire.

Agropolis is the name for the similar effort in agronomy and agricultural biotechnology, the core of which is the complex of government laboratories with interests in food and agriculture, between them employing an estimated 1,800 people.

There is also what Montpellier calls its Euromedicine park, to which the city has attracted more than 20 businesses and research laboratories in the fields of pharmaceuticals and medical instrumentation.

What stands out from these endeavours is that the public laboratories are more than merely compliant, they are encouraging. It is public policy not only that France should increasingly rely on technology for its prosperity, but that neighbours with interests in research may be a source of research contracts, perhaps even of better jobs. □



Catalytic cracking plant Elf style.

through an air-driven regenerator whose chief function is to remove solid carbon, or 'coke', from the catalyst (see figure).

In the drive for increased gasoline output, schemes for the hydrogenation of heavier crude fractions are being canvassed, further complicating the optimization of cracking plants.

At Solaize, the joint Elf-CNRS team has been forced back to basics, fitting a pilot-plant housed in a hangar-like

building with instruments and using radioactive tracers for tracking the movement of zeolite through its cycle. The objective is to refine a mathematical model of a cracking plant which is being elaborated, with the objective of fixing the parameters of more efficient cracking plants linked with hydrogenation units. The same model will eventually be the basis of programs for the automated control of refinery operations.

Bernard enthuses about the niceties of the operation of standard cracking plants which the study has brought to light. Even questions such as the effect of the riser walls on the movement of zeolite had previously gone unanswered, he says. That there should be friction had been expected, but the velocity profiles across the riser that have now been measured, and the patchiness of zeolite concentration across the riser, were not expected.

Nobody at Solaize is able to say what the economic benefits of the programme will be. Rather, the assumption seems to be that a business which depends on the successful operation of machines such as cat crackers had better understand them in as much detail as it can.

Elf is not alone among French companies in having taken a deliberate decision in the past decade to spend more

of its effort on basic research. Claude Jablon, corporate director of research, says that the company (which differs from more conventional oil companies in its strong interest in chemicals and pharmaceuticals) employs 4,500 people in research laboratories scattered through France, elsewhere in Western Europe and in North America. Of this effort, engaging some 4 per cent of the company's total staff, he reckons that 10 per cent is devoted to projects that will yield benefits only in the long term.

Just where the project to develop better asphalt fits in this is not clear. The company appears to have something of a success with a material called 'Styrelf', selling 300,000 tonnes a year of it. The idea is that hydrocarbon molecules of regular asphalt (non-volatile refinery fractions) have been covalently linked with styrene to form a kind of three-dimensional molecular network in which road metal (graded granite fragments) for highway surfaces can be embedded. Energy is being spent on the materials testing of various compositions of road surfaces, but, in the absence of a full understanding of why highway surfaces wear out or become distorted, faith is required to assure highway authorities that polymeric asphalt will last longer. □

SPACE

Is there profit as well as pride?

OVER the past 25 years, France has emerged as the European leader in space technology, continuing to push forward and take expensive risks while its neighbours got cold feet. This fits with the high profile given to technology.

The academic elite graduating from the *grandes écoles* are called 'engineers', and electronic gadgetry sprouts regularly in Paris, from video in the metro stations to cable television. The Minitel telephone-linked interactive videotext system is the most successful in the world and France's high-speed trains (TGV) and modern metro systems are often cited as models elsewhere. High technology is seen as the key to economic survival in the next century.

France has had its own space programme since 1962, when the Centre National d'Etudes Spatiales, the national space agency, was founded. In 1975 it abandoned its own domestic rocket programme to cofound the 13-member European Space Agency (ESA).

Now, France contributes almost a third of ESA's \$1,700 million budget, ahead of Germany and Italy and four times as much as Britain. It is no accident that ESA headquarters are in Paris, that the European commercial launch consortium — Ariane-space with 50 per cent of the world market — is based in France, or that the first

European cosmonaut was a Frenchman.

Always an enthusiastic partner in ESA, France pulled out all the stops at the 1987 ministerial meeting in The Hague, at which the agency's long-term plan was approved. The Hermes space plane developed by CNES was chosen to service the Columbus platform, intended as Europe's contribution to the US Freedom space station, despite criticism from Britain that the technology was out of date and that

the plane was too small.

But the price of the acceptance of Hermes is that France has to foot 45 per cent of the bill, a cool FF597 million in 1990. Furthermore, Hermes depends on a new generation of heavy-lift launcher, Ariane 5, to get into space and this, too, is 45 per cent French, with costs to France running at FF1,812 million this year.

But while Britain decided that the Hermes and Ariane 5 package was simply too expensive and dropped out, France found it had money to spare to boost its domestic space programme. In the 1990 civil research budget, CNES received FF7,187 million — almost 16 per cent of the entire budget and 11 per cent more than 1989.

Of this, FF352 million will go towards a fourth generation of the SPOT commercial remote-sensing satellite owned by CNES, which will have cost an estimated FF2,500 million by the time it is launched in 1995. Although SPOT loses money, its freely available high-resolution photographs have proved a thorn in the side of superpower defence departments and a way to vaunt France's prowess.

As European space technology has a distinctive French tinge, it is fitting that the new director of ESA should be a Frenchman, Jean-Marie Luton, who came from CNES. And with some tough negotiating ahead as the full costs of Hermes and Ariane 5 emerge, Luton will need all the backing he can get. **Peter Coles**

IMAGE
UNAVAILABLE
FOR COPYRIGHT
REASONS

Ariane 5 will launch Hermes — both products of French initiatives.