SCIENCE AND TECHNOLOGY

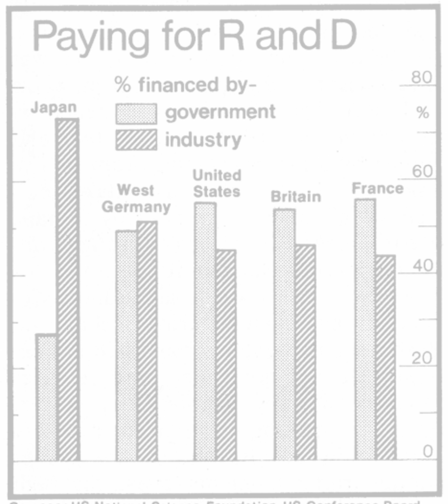
America tries to cure its innovation blues

NEW YORK

One aim of the $15 billion in tax cuts promised to industry last week by President Carter is to encourage innovation. The American president shares a widespread view that America is slipping badly in the technological race to launch new products and processes. Is it?

The evidence is patchy. There are plenty of examples of Yankee ingenuity still alive—in microelectronics, biotechnology, solar energy and so on. The fear is that more vigorous innovators (that is, Japan and West Germany) have invested heavily and narrowed the technological gap. The number of patents issued in America to foreigners has more than doubled over the past decade to 38% of all patents. Mr Derek Price, the Yale science historian, estimates that, whereas America accounted for a third of the world's science and technology in 1967, it now accounts for only a quarter.

The amount America spends on R and D as a share of gnp has certainly slipped—from 2.6% in 1970 to around 2.2% today. The Soviet Union remains the biggest spender on science percentage-wise, followed nowadays by West Germany. Science budgets are rising fast in Japan, too. On top of that, both Japan and West Germany spend proportionally more of their R and D money on non-military projects. Over 60% of government support for R and D in America is tied to defence and space research.



Sources: US National Science Foundation; US Conference Board

Industrial innovators have a number of grouses—some real, some illusory. Like:

- The high cost of meeting regulations. Meeting regulatory requirements has diverted scientists and engineers from profit-generating research.
- The low rate of capital formation (for which taxes get blamed).
- The impact of inflation on incentives to invest in innovative (ie, risky) processes. Allowable depreciation is based on historic cost rather than replacement cost. That matters since anything from 50% to 90% of the cost of innovation comes when prototypes or demonstration plants have to be built to see if laboratory ideas can be scaled up profitably.

The Committee for Economic Development, an industry-sponsored body, says the first priority of government must be to get more rapid depreciation of assets. Both the White House and congress agree. Something like a 40% faster write-off is likely to emerge from the current tax-cut wrangling. The industry-based committee would also like to see tax credits doubled (to 20%) for all R and D facilities. And it suggests that tax credits should be available on any grants industry gives for university research.

At present, the American taxman treats innovation much like any other business expense but with some significant differences. Normally, a tax deduction can only be made on spending incurred "in carrying on" an existing trade or business. By contrast, deductions can be set against R and D outlays made simply "in connection with" an existing business or trade. This distinction is particularly useful for individual investors or small entrepreneurial firms earning their keep from selling patents and know-how.

Moreover, inventors' patents are not considered to be business stock, so no capital gains tax is paid when an inventor sells his own patents. However, companies have to pay tax on the sale of patents developed by their employees. And there is no special relief for companies designing and installing facilities to produce an innovation for the first time, or to test it on a near-commercial scale. Nor are there any tax incentives (other than those generally available for investment) for buying special test rigs and experimental equipment. And some might ask, why should there be?

American manufacturers believe their main overseas competitors fare better. Japan provides special accelerated depreciation allowances for investments in new technology. French and West German firms get tax allowances for all equipment devoted to R and D. Japanese companies forming joint research associations can write-off immediately all the costs of equipping their research facilities. The West German government offers a 7.5% tax-free cash subsidy towards R and D facilities.

American industry wants to eat its cake and have it, however. Besides asking for tax incentives for innovation, it is also arguing for increased government spending on R and D. The Carter proposals do, in fact, aim to raise federal R and D spending by a real 3% annually for the next two years, bucking a trend: during the 1960s, the government financed more than 60% of America's R and D; now it pays for around 50%.

Perhaps Washington should support less, not more. Governments in Tokyo and Bonn have both made industry pay for most of its own R and D in the 1970s (see chart). Research is most likely to lead to innovation if it is done in the institution that will apply it.

Biochemistry

Backers, please

Nobel prizewinners usually spring from big universities or commercial laboratories—and can count on generous budgets to follow up their seminal ideas. Not so the British winner of the 1978 prize for chemistry, Dr Peter Mitchell. Having left university life for health reasons, since 1963 he and a small team have been working in their own private charitable research institute near Bodmin in Cornwall. The institute is now faced with possible closure. The reason: inflation.

While prudent investment has doubled the value of the institute's original endowment, British prices have quintupled.

Any would-be rescuer will have to be a pure philanthropist. Dr Mitchell's team is engaged in basic research. Like all basic research that changes man's understanding of the fundamental mechanisms of his world, it is likely eventually to have "practical" (ie, commercial) implications. But the linkage of theory to practice may be indirect and certainly will not come overnight.

Indeed, the so-called chemiosmotic theory that won Dr Mitchell his Nobel prize was so revolutionary that only now are its detailed implications being explored. The first job was to get the hypothesis itself accepted. That took the best part of 17 years, from 1961 when Dr Mitchell first proposed it (while still at Edinburgh University) to the time he won his prize.

Contributions to make

The problem to which Dr Mitchell found the key was how living cells harness the energy they need. Scientists knew the ultimate source of the energy: for plants, the photosynthetic processing of sunlight; for animals and bacteria, the oxidation of food (sugars and fats). They also knew how cells eventually stored the energy derived from these sources: by synthesising a specialised molecule called ATP. What eluded them was the link between energy gathering (eg, oxidation) and energy storing (ATP synthesis).

Most scientists assumed that the link was provided by specialised molecules dissolved within the soupy interior of cells. Awkwardly, a decade's intensive search failed to turn up the expected molecules.

Dr Mitchell's solution to this quandary was to propose that the link between energy gathering and storage is provided as much by the cell's structure as by the cell's chemistry. He focused attention on the membranes that partition the interior of cells. Most scientists had previously regarded these as being as functionless as the walls of a factory, but Dr Mitchell's theory gave them a key role.

Consider the case of animal—including human—cells. Within these both energy gathering and storage take place in specialised subunits called mitochondria which are separated from the rest of the cell by membranes. Both the enzymes which oxidise the cell's food and those which synthesise ATP are embedded in these membranes. In simplified terms, Dr Mitchell's theory says that the two sets of enzymes are linked as follows:

- the enzymes which oxidise food also transport protons to the outside of the mitochondria, into the cellular fluid. They do this by splitting molecules into negatively charged ions and positively charged protons, which are carried through the membrane.
- this concentration of protons outside the mitochondria creates an imbalance. Not only is the fluid outside the mitochondria (with its higher concentration of protons) more acidic than that inside, it is also (relatively) positively charged.
- trying to remedy the imbalance, protons naturally flow back across the membrane. As they do so, their energy is harnessed to drive the synthesis of ATP, much as the energy of water falling on a watermill is harnessed.

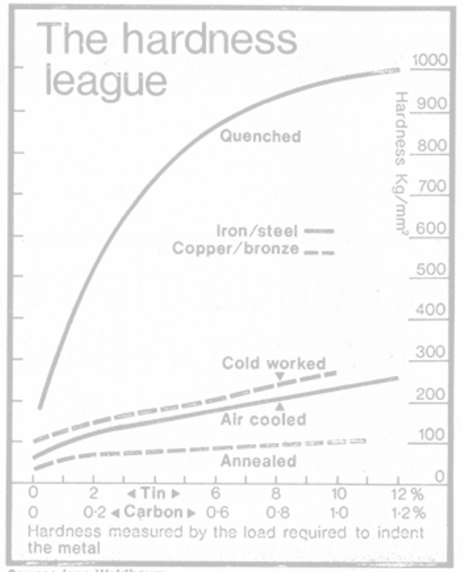
The theory is neat. In broad terms, moreover, it holds true not only for the mitochondria of animal cells but also for bacteria and the chloroplasts of plant cells. But scientists have yet to work out in precise detail how membranes are structured to tap the energy of the proton flow across them. Doing so will provide new insights into the mechanisms of cells and could provide new techniques for controlling man-made chemical reactions. It would be nice to be sure that Dr Mitchell's team will be able to carry on helping to elaborate his insights in its Cornwall retreat.

Iron-age technology

A step backwards

Till recently, archaeologists thought they had an easy answer as to why, about 3,000 years ago, iron began to replace bronze in Europe. Iron, they said, was invented by the Hittites who closely guarded its secret; when the Hittite empire collapsed around 1200 BC, the secret was let out of the bag; and, iron being far superior to bronze, it was soon adopted everywhere.

That theory is now exploded and archaeologists are coming to accept a new one: that the iron made 3,000 years ago was actually far inferior to bronze and that the main reason why iron was adopted was a shortage of tin with which to make bronze. The poor Hittites have even lost their claim to have invented iron. It was being made in distant Thailand by 1600 BC.



Source: Jane Waldbaum

This is yet another nail in the coffin of the "diffusionist" theory that dominated archaeology till a few years ago. Diffusionism says that each of the great inventions—farming, metallurgy, writing, etc—occurred only once, usually in the near east, from whence it diffused to the rest of the world. Modern research has disproved the diffusionist argument again and again.

In the case of the iron age, the demolition work has been done by an American archaeologist, Dr Jane Waldbaum. She has shown that the use of iron was widespread in the eastern Mediterranean during the bronze age itself; that, until the tenth century BC, bronze was universally preferred for the majority of tools (especially weapons), and that iron tended to be restricted to cooking pots and jewellery, uses in which its alleged advantages over bronze would not be of value.

Earlier archaeologists had mistakenly assumed that, because modern iron is a far better metal than bronze, so was ancient iron. Pure iron and copper are both soft. Iron can be strengthened by the addition of carbon (making steel) and copper by using tin (making bronze). The amount of carbon needed to make good steel is far higher than is likely to have been achieved by chance, through contamination in a charcoal fire.

As the chart shows, final hardness also depends on manufacturing techniques. Both metals benefit from skilful heat treatment and good steel also requires rapid cooling by quenching in water. Early iron-making would have been very much a hit-or-miss affair. Analysis of antique iron implements reveals that high