Science in an era of political change

With peace under way, and bright immigrants pouring into the country, Israel has a huge opportunity to maximize the potential of its strong science and technology base. Get it right, and its future will never have been brighter.

THE historic handshake between Yitzhak Rabin, Israel's prime minister, and Yasser Arafat, the leader of the Palestinian Liberation Organization (PLO), promises to bring peace to the Middle East. It is now being followed by another handshake, this time between peace and science, that promises to help bring prosperity also.

On the one hand, scientific cooperation between Israel and its Arab neighbours is reinforcing peace by contributing to dialogue, and also by helping to replace national competition with regional cooperation aimed at better management of scarce resources, protecting the environment and fighting disease.

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The peace process, in turn, promises to benefit the entire research enterprise both in Israel and throughout the Middle East. Immediate returns will come from the extra funds that will flow towards joint Arab–Israeli projects from foreign countries and organizations with an interest in sustaining peace.

But the major benefits of peace to science and technology will probably be more indirect, and will result from the expected increase in economic growth and foreign investment.

Economics, not politics, is what mainly affects research support in Israel, says Haim Harari, the president of the Weizmann Institute, as there is otherwise broad political consensus that research and education are important. He predicts that the outcome of the 1996 general election will have little direct effect on research provided that growth continues.

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The current period of economic growth, he adds, means that "now is a very good period for science".

The biggest effect of the peace process on Israel's economy is likely to be the decision by the six countries of the Gulf Cooperation Council to end the so-called secondary and tertiary "Arab boycotts", which prohibited trade with companies doing business either with Israel or with other companies trading in Israel.

The decision, announced last year at the first Middle East/North African Summit in Casablanca, in which Israel also participated, will lead to a massive increase in foreign investment, predicts Shuki Gleitman, chief scientist at the ministry of industry and trade, in particular from countries such as Japan which depend heavily on Arab oil.

The lifting of restrictions by Arab countries on direct trade with Israel, also announced at the summit, will also lead to greater regional cooperation on gas, water and electricity infrastructures, but is itself unlikely to have much effect on Israel's economy.

More than 60 countries that previously avoided doing business with Israel have now opened diplomatic and economic relations. Many of these countries are also new emerging economies in Asia and the Pacific Rim, and Israel, which has until now been excluded from around two-thirds of the world's markets, has an opportunity to go on a selling spree.

Moreover, economic analysts reckon that what Israel will mostly be selling will be high-technology products, which have increased their share of Israel's exports from less than 40 per cent in 1989 to more than half last year.

But if Israel is to take advantage of these opportunities, it will need to maintain its strong science base, radically improve its systems for technology transfer and address the notorious weakness of its companies in marketing and selling technologies in the international market. □

Science and peace

SCIENTIFIC cooperation between researchers in Israel and their colleagues in neighbouring Arab states is making an important contribution to political efforts to bring peace and stability to the region, by helping to bring down the barricades that have separated their countries for almost half a century.

Seminars on "science and peace" have become almost a fashion. In April, for example, the "First Israeli–Arab Scientific Meeting" was organized in Paris, by the prosaically titled "French Association on Behalf of Cultural and Scientific Exchanges between Middle-Eastern Peoples". In May, a "Conference on the Peace Process and the Environment" was also organized at Tel Aviv University.

"Science is less political than other issues, it's a bridge for peace", says Leah Boehm, chief scientist at Israel's science ministry, on her way to a meeting aimed at launching a programme to enable Jordanian postgraduates to take PhDs in Israel.

Avi Golan, a researcher at the Jacob Blaustein Institute for Desert Research at Sede Boker, has also recently begun cooperating with Egyptian researchers on the biochemistry of desert plants. "It's fantastic," he says, "I fought against

Bethlehem University.

Science in Israel

This survey has been written by *Nature*'s European Correspondent, Declan Butler, who wishes to thank Paul Ogden and his staff at the Weizmann Institute, Esther Koslovsky at Tel Aviv University, Jerry Barach at Hebrew University, and Uri Stein at the science ministry, for their help in arranging interviews, often at very short notice. Thanks also to Sonia Chanaz for editorial assistance, and Baruch Raz and Dori Goren at the Embassy of Israel in Paris, for help in making arrangements. Apologies to those whose work, for reasons of space, has not been described in detail.

Egypt in the 1967 war, now we're working together."

But when Israelis speak of cooperation, some Arab scientists fear that this will be fuelled by Israeli brains, outside money and Arab 'technicians'. The basis of their fears is a sensitive issue, but can be simply stated. Israel has spent much more on science than its Arab neighbours, and is more advanced in almost all areas of science.

What is true for Israel's established Arab neighbours is even more true for the West Bank. "We are at a big disadvantage, we don't have the universities, infrastructure, or money that the Israelis have," admits one West Bank scientist.

He argues that cooperation "is a must", not only to help peace but to help Palestinian universities develop, but says that "if the Israelis want cooperation, they should open their universities to us. We have the academic talent, cooperation has to be symmetrical".

Such arguments hold little sway with some Israeli universities, however. "The Palestinians want help to develop, but we don't have the resources for this," says Hanoch Gutfreund, president of Hebrew University in Jerusalem. "We don't even have that sort of collaboration with Tel Aviv University, we're not here to help universities compete with each other."

Cooperation is a "breakthrough", says Gutfreund, "that is important for the region". But he argues that there is no point yet in collaborating in areas of high technology. Instead, he favours forms of cooperation where Israelis and Arabs can be "on a equal basis", and where projects are of regional interest and also likely to attract international funding.

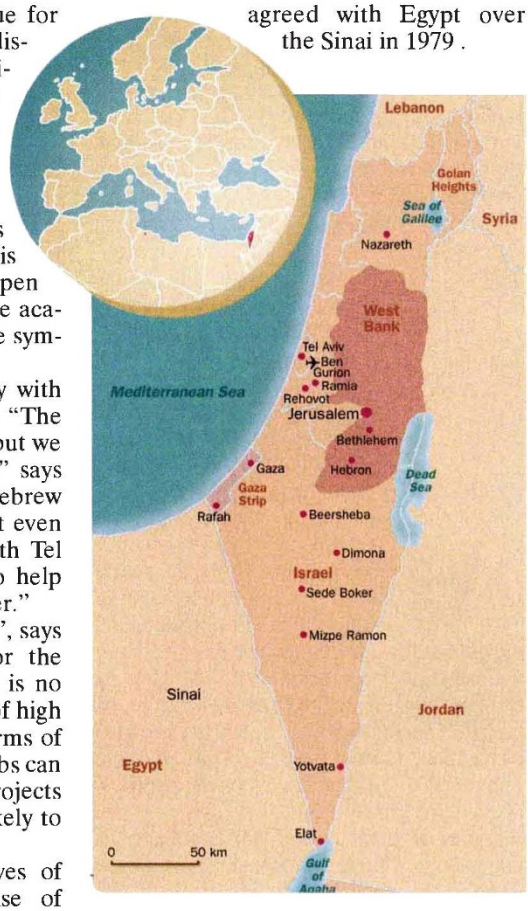
Indeed, apart from the initiatives of individual researchers, the promise of international funding seems the biggest carrot for cooperation. The United Nations Educational, Scientific and Cultural Organization (UNESCO), for example, has agreed to fund a plant biotechnology centre at the Bethlehem University that will also involve Israeli researchers.

Boehm, for her part, is chasing funds from the United States and Germany to set up a programme with Jordan aimed at studying environmental protection, irrigation, water remediation and insect problems in the Jordan Rift Valley. With two sons serving as paratroopers, one of whom is stationed in Lebanon, she admits to having more than a professional interest in peace. □

The politics of peace

PEACE talks between Israel and the neighbouring Arab states began with the Madrid conference in 1991. Since then Israel has signed a framework for peace with the PLO, made peace with Jordan after 46 years of hostility and opened discreet diplomatic relations with other Arab countries.

The key to stability in the region will depend on Syria and Lebanon making peace with Israel. Last month, Israel accepted that it should leave the Golan Height, opening the way to negotiations with Syria that could lead to Israel's withdrawal from the area in a similar "peace-for-land" settlement to that agreed with Egypt over the Sinai in 1979.



Jerusalem remains the joker in the peace process pack. Radical Palestinians will not settle for less than Jerusalem as their capital, while Israel is unlikely ever to compromise on giving back parts of Jerusalem.

But the future of the peace process will depend mainly on the outcome of the 1996 elections, when Israelis will elect 120 representatives to the parliament, or Knesset, under a system of proportional representation.

No party has ever obtained a majority in the Knesset, and horsetrading to form coalition governments is the rule. Coalition governments led by the Labor party, a social-democratic group which originated from the pre-state Jewish leadership, ruled Israel from 1948 to 1977, when the right wing Likud (consolidation) party came to power. Labor regained power in 1992.

Likud is a coalition including Herut (Freedom) and the Liberal party, which historically has owed much of its success to its defence of disadvantaged Sephardic Jews from the Middle East and Africa. But the party has turned towards the ideology of a 'Greater Israel' inherited from Herut, taking up the cause of the occupied territories and siding with the extreme right against Rabin's peace deal with the PLO.

Indeed, what distinguishes the two main parties is that Labor favours territorial compromise, while Likud does not. Otherwise, left and right have few economic connotations in Israel; both Labor and Likud support the free market, privatization and deregulation.

Recent polls showed the current prime minister, Yitzhak Rabin, of the Labor party lagging behind his Likud rival, Binyamin Netanyahu. This month, however, Likud was weakened after David Levy, Netanyahu's main rival in Likud, left to set up his own party. With Likud divided, a Labor victory in 1996 will mainly depend on Rabin convincing Israelis that the peace process is good for them. □

Occupational hazards

BETHLEHEM lies in the occupied territories just 20 minutes' drive south of Jerusalem. But the distance seems much larger for the Palestinians queueing in the sun either to obtain permits to enter Jerusalem or to cross the frontier checkpoint itself.

"Freedom of movement" remains the biggest problem for researchers in the West Bank, according to Moien Kanaan, the chairman of the department of life sciences at Bethlehem University. Kanaan himself has a Jerusalem identity card that allows him to cross the frontier as he pleases, except during the frequent periods when the Israeli Army closes it. Earlier this year, the border was sealed for several months, following attacks on Israel by Palestinian groups.

But many of Kanaan's colleagues face much greater difficulties because they need to obtain travel permits even for a short visit to the nearby Hebrew University in Jerusalem. "The policy for authorizing such permits remains "completely arbitrary", says Kanaan.

Depending on the mood of the official behind the window", he claims, "you will get a permit for a month, a week or just two days, and it can be cancelled any time the Israelis want." As a result of such difficulties, most researchers ask the university to apply for permits on their behalf, as it "carries more weight".

Kanaan admits that the peace talks are making it easier to get permits, and that border closures have become less frequent. But he complains that the time, effort and humiliation involved show that the Israelis still have the "mentality of an occupier". "Being a Palestinian is still a problem", he says. "The Israelis have yet to understand the dignity and human factor."

Moien N. Kanaan (above). "Freedom of movement" remains the biggest problem for West Bank scientists.
Students at Bethlehem University (left) celebrating the victory of the pro-Arafat, pro-peace talks party in student elections last month.

Kanaan does not consider himself a political radical. His education, he says, allows him to entertain the idea of peace even though the benefits are not yet "felt in the streets". But he is concerned that many Israeli actions, such as last month's attempt to annex Arab land close to Jerusalem, make it more difficult for academic liberals like himself to defend their support for the peace talks.

The political situation also continues to inhibit Palestinian researchers from cooperating with their colleagues in Israel. "We want to cooperate, but why should we go and normalize our relationships when the Israelis here make our life miserable, when we can't cross the border to meet in Hebrew University which is just down the road?", asks one Palestinian scientist.

Such reasoning is also followed by the Palestinian Higher Council for Education, a body elected by the four West Bank universities. It recommends that normal relations with Israel should not be pushed too fast, given that political negotiations between Israel and the West Bank are far from complete. "It's too soon to go and hug everybody."

Despite the difficulties, Kanaan says he is "glad" to have returned to the West Bank three years ago, after having worked in laboratories in the United States for almost a decade. "I enjoyed the liberal way of life in the States, but I prefer to combine this with the community values we have here. I and my family are oriental in our hearts."

Returning has also meant making do on a monthly salary of US$1,200, high by West Bank standards but difficult to live on nonetheless. Similarly, money and equipment for research are badly lacking at the university — a liberal school that focuses on teaching — especially in expensive disciplines such as molecular biology,

Kanaan himself researches the genetics of local diseases, pointing out that the large extended families common in the West Bank are ideal for pedigree studies. He is also genotyping methicillin-resistant strains of *Staphylococcus aureus*, an epidemic strain that is a big problem in local hospitals.

"My eyes are hurting from writing grant applications", says Kanaan, who receives only a small research stipend from the university. The trick, he says, "is to examine the priorities of international funding agencies to find ones that match those of the West Bank."

The life sciences department has also recently obtained funding from UNESCO to build a plant biotechnology centre that will use tissue culture techniques to produce virus-free vines, for example, and also carry out research on drought-resistance genes. "The peace process is providing more opportunities for us to get money for research and travel abroad," says one researcher.

But although many Palestinian researchers welcome the increase in opportunities for foreign travel, many would nonetheless prefer improvements in travel restrictions to Israel. "It makes no sense for me to go to Europe every summer, when I could learn the same techniques down the road, and come home at night", points out one scientist. □

Refusenik researchers return

An Israeli particle physicist was perplexed one day when the office cleaner suddenly asked to have a look at a calculation that the academic seemed unable to solve. The physicist was astonished a few minutes later when the cleaner, grinning like someone who has just finished someone else's crossword, handed him back the solution.

Whether this anecdote, variants of which are told from Dan to Beersheva, is true, is difficult to say. But it captures the situation of some of the 17,000 immigrant scientists and engineers who have arrived in Israel since 1989 but been unable to find jobs in their original professions. Indeed, at least one engineer does work as a cleaner at the science ministry itself.

Following the decision by the Soviet Union in 1989 to let its Jewish citizens emigrate, some 550,000 'refuseniks' have arrived in Israel, swelling its population by 10 per cent. Providing housing and jobs for such numbers —equivalent to the United States absorbing half the population of the United Kingdom over a period of four years — has demanded a huge national effort.

Such massive immigration, or *Aliya*, is nothing new to Israel. The state was created in 1948 by gathering in around 650,000 Jews from more then 100 countries of the diaspora. Over the next three years, 700,000 new immigrants arrived, and a similar number again during the 1950s. The "right to return" of any Jew is still taken for granted.

What distinguishes the latest wave of immigrants from those earlier ones is precisely that many are better educated or trained than the native population. Before 1989, Israel had the world's highest proportion of scientists or engineers — 130 per 10,000, compared with 77 in the United States, and 73 in Japan — and Soviet immigration has increased this number by more than half.

"It is the most important event since Israel's creation", say Zvi Yanai, the director general of the science ministry. "It's the biggest influx of scientists since the flood of scientists from Europe to the United States after the Second World War.

Indeed, the arrival of highly qualified scientists has boosted disciplines throughout universities and research institutes. The mathematicans are "outstanding-plus", says Haim Harari, the president of the Weizmann Institute, where immigrants at one point accounted for more than three-quarters of PhDs in mathematics. Similarly, Russian immigrants now account for a quarter of faculty in the mathematics institute at Tel Aviv University.

Immigrants have also been manna from heaven for the country's electronics and computer industries, which badly lack qualified engineers and scientists. "The immigrants really saved our companies," says one official, "by providing a timely stop-gap"; and also "cheap labour", say cynics.

But while the best scientists, or those whose skills match industrial needs, have easily found jobs, around 2,000 immigrants, many with good qualifications, have been unable to find jobs in their own areas, if at all. This is particularly true in the cash-strapped universities, which cannot afford

to support many new staff, and in hospitals.

With 9,000 physicians, for example, Israel had more than it needed before immigration began. Similarly while electro-optical engineers are almost guaranteed a job, a railway engineer has little hope in a country where railways are not a priority.

The numbers of jobless immigrant scientists are also likely to rise in the coming months, as government support schemes, on which they have previously relied, begin to expire. "Getting money is a constant battle", says Harari.

The government has provided all immigrants with a package of cash and allowances, but then left them to sink or swim. Similarly, while the ministries of science and immigrant absorption have provided around 6,000 immigrant scientists with a small salary to enable them to "find their feet" within existing research group, this lasts only two to three years.

Eliezer Gileadi, professor of chemistry at Tel Aviv University, has led a campaign to persuade the government to support a new scheme to provide extra money for immigrant scientists. Otherwise, he argues, "all hell would break loose".

The Gileadi Plan, as it is officially known, would provide immigrant scientists with half the mininum monthly salary, about US$1,200, and leave them to seek the remainder from other sources. In April, the government agreed to fund 300 such posts for three years, and Gileadi hopes it will agree to a further 200 and also make posts renewable until researchers reach retirement age.

"As the inventor of this programme, I have the moral right to say it's a bad programme, a compromise", says Gileadi. "We are privileged to have a brain drain towards Israel for once, but unfortunately can't maximize this advantage."

One area where the brain drain is being maximized is in intelligence. Immigrants have provided Israel with Russia's last secrets in space and nuclear technology, according to observers, and have supplied the information on materials needed by Israel to complete its Merkava tank.

Despite the many problems it would be a mistake to declare absorption a failure. "It was an amazing feat given the challenge", says Harari, who points out that many scientists in precarious positions will gradually climb the ladder to better jobs. □

Incubating immigrants

ISRAEL'S unique Kibbutz system of communal living has accumulated enormous debts, and is increasingly under fire for becoming a conservative lobby whose main aim is self-perpetuation at the expense of the taxpayer. This has done little, however, to dampen Israeli enthusiasm for innovative and large-scale social engineering.

Faced with the flood of immigrant scientists, the government has embarked on a nationwide scheme to turn their expertise into research-based, export-orientated companies, in no less than two years, by setting up a series of "technology incubators" (TIs) across the country.

The incubators themselves are nonprofit umbrella structures, set up in association with either academic institutions, local councils or private companies, each of which houses several start-up companies. Immigrant scientists account for four-fifths of company staff, and for half of the business ideas. So far, 28 incubators have been established, housing a total of 240 new companies.

The idea of the incubator is to provide immigrants with a safety-net while they get to know the ropes of a market economy. The TIs themselves provide immigrants with training in negotiating skills, project management and free legal aid, and help them to find outside partners and investors. All the incubator's running expenses are covered by the ministry of industry and trade (MIT) up to a ceiling of 325,000 shekels a year.

To enter an incubator, immigrants must be "entrepreneurial", say Shuki Gleitman, chief scientist at MIT. The incubator then carries out a patent search on the immigrant's idea, and prepares a preliminary business plan for his company.

MIT also pays 85 per cent of each project's annual costs, including 100 per cent of salary costs and 75 per cent of other expenses, up to a ceiling of 300,000 shekels, but entrepreneurs must find the remaining 15 per cent themselves. The scheme will cost MIT US$33 million this year.

Such explicit government interventionism would bring tears to the eyes of even the most reasonable of free-marketeers. But a handkerchief is waiting. After only two years, all subsidies to the startup companies are withdrawn, and they must fend for themselves in the marketplace. Moreover, if they succeed, they must pay back MIT's original investment.

So far, 140 companies have reached this point, and 70 have survived, according to Gleitman. He boasts that Nanometre, a company created at the Technion incubator which has developed a motor of nanometric dimensions, is valued at US$10 million. But he is also first to admit that "we don't have 70 Microsofts. This is not an employment solution; it's absorbing people and their technology."

But if many Israeli scientists are sceptical whether the incubators will make a major impact on the economy, the odd success story aside, most nonetheless applaud the scheme as an "imaginative and excellent solution to exploiting the potential of immigrant scientists". Indeed, one cynically suggests that a similar scheme should be used to "get the best scientists out of the universities and into industry". □

"At home in Zion"

To create the state of Israel, Zionists resurrected and revised a language that had been dead for almost 2,000 years. Learning Hebrew, at specially arranged crash courses, or *Ulpan*, is also one of the first tasks facing immigrants such as Isak Beilis, who arrived in Israel in 1991 after having been a a senior research scientist at the Academy of Science's Institute for High Temperature in Moscow.

Beilis now works with a group of six other immigrants in the Faculty of Engineering at Tel Aviv University. The Electrical Discharge and Plasma Laboratory, which is led by R. Boxman, is developing vacuum arc techniques for rapid deposition of high-conductivity transparent coating, for uses such as flat-panel displays, solar cells and museum burglar alarms. It has also developed a process that speeds up the case-hardening of steel from one day to one-tenth of a second.

Their research on "arcs and sparks" is directly connected with the Hebrew word for electricity, points out Boxman proudly. Because electricity had not been discovered in biblical times, language revisionists had to invent a new term, and they chose "amber" or "Hashamal" in Hebrew, after the amber arcs in the clouds seen by Ezekiel during a vision.

Beilis, who is renowned for his research on electrode phenomena in vacuum arcs, and plasma physics, spent his first six months in Israel working in the laboratory without pay,

Isak Beilis, concerned for the future.

and making ends meet on a small stipend from the Jewish Agency. He has subsequently received around US$1,000 per month, as part of a three-year Wolfson grant, one-third of the average salary of his colleagues.

Most of these grants expire soon, however, and Beilis admits that he is "concerned for the future". But he says he is nonetheless "happy to have had the opportunity to come and work in my field, that's the most important thing for me".

His wife, an electrical engineer, has been unable to find a job in her field, and now cares for elderly people. But the future for Beilis's teenage son seems bright. He has already taken third place in Israel's Mathematics Olympics, and been invited to join the Israeli team competing in the International Mathematics Olympics. □

Research organization: a coat of many colours

"ISRAEL is lucky not to have a centralized research system", says Haim Harari, president of the Weizmann Institute. "It's extremely dangerous in a small country to have central control." Harari does not risk losing sleep. The official diagram explaining who sets science policy and allocates funds in Israel looks as if its designer was experimenting with new flowchart software.

Eleven ministries have their own office of chief scientist, for example, most with a budget of around 3 million shekels, and each pursues its own policies. This decentralization results from the recommendations in 1968 of a commission chaired by Ephraim Katchalski-Katzir, a professor at the Weizmann Institute, and later the fourth president of Israel.

The defence ministry also carries out military research through its wholly owned armament development authority, while the prime minister's office controls the Israel Atomic Energy Commission. The National Council for Research and Development, which Katchalski-Katzir recommended should be responsible for setting national science policy, has ended up as an advisory body to the ministry of science and arts (MOSA).

The gravity needed to prevent the entire structure flying apart is supplied by the mass of ministry of industry and trade (MIT) and MOSA. MIT, in particular, has a massive budget, US$450 million this year, for subsidizing industrial research, including 28 "technology incubators" aimed at absorbing immigrant scientists (see page 720).

MOSA lacks the financial muscle of MIT, but compensates by trying to coordinate almost anything with the word 'science' in it. The science minister, for example, chairs the ministerial committee for science and technology, and the chief scientists' forum. MOSA has also recently launched a national strategy for generic research (see below), and coordinates Israel's participation in international research organizations. The Israeli Space Agency (page 724) is also affiliated with MOSA.

The main source of funding for basic research is the Council for Higher Education (CHE), which has a total annual budget of around US$1 billion. Most of this goes on salaries and overheads, however. Only about 15 per cent of a university's basic research budget comes from its own sources, including government allocations, and most researchers need to look elsewhere to obtain money for their research.

They are not spoilt for choice. Indeed, the proliferation of funding sources is such that each university has a 'research authority' that brings funding opportunities to the attention of researchers, and reminds them of deadlines for proposals.

Hebrew University's research authority, for example, brings in about US$41 million of external research funds annually. About three-quarters of its research is basic, and half of the remaining applied research is supported by company grants.

Shulamit Aloni: science minister since 1993.

An effort to establish an analogue of the US National Science Foundation is also meeting with some success. Government funding for the Israel Academy of Sciences and Humanities, which administers Israel's National Science Foundation grants, should rise from US$15 million last year to US$20 million next year. Add the academy's US$2 million income from private sources, and it becomes the biggest Israeli programme of its kind. It has already become the biggest source of funding at Tel Aviv University.

But most of the money available still comes from foundations established with foreign countries. The US Binational Science Foundation (BSF) was set up in 1972 with endowments of US$30 million each from Israel and the United States. A US$40 million increase in 1984 raised BSF's capital to US$100 million, and this now yields around US$7.5 million annually. To qualify for a grant one must have a bone fide collaborator in the United States.

A similar German–Israeli Foundation (GIF) was established in 1988, with DM150 million contributed by both governments. A United Kingdom–Israeli fund set up last year will also provide £600,000 over three-years, while MOSA is also discussing the setting up a fund with China.

Earlier this year, US President Bill Clinton, and Yitzhak Rabin, Israel's prime minister, also created a US–Israel Science and Technology Commission to promote development of technologies and high-technology industries, and the conversion of military technologies to civil applications. Each government contributed US$15 million over three years, and companies are expected to match this sum.

Besides these foundations, bilateral agreements with organizations such as the US National Institutes of Health provide additional funds. Germany's Max Planck Society and the Weizmann Institute have also established the Minerva Foundation to administer a joint programme of research. Israel is also to join the European Union's Framework research programmes (see page 723).

Harari supports such diversified funding. "It's good to have to scramble for money", he adds, pointing out that the Weizmann Institute previously obtained only US$4 million from industry, but now gets US$13 million. "We wouldn't have achieved this is we had been fully funded by government."

But he nonetheless warns against Israel becoming too "dependent" on foreign money, and allowing this to influence research priorities. Hanoch Gutfreund, president of Hebrew University, argues, however, that the government should itself commit sufficient funds to meet basic research needs.

MOSA seeks promised land

ISRAEL'S ministry of science and arts (MOSA) is embarking on a scheme, similar to that endorsed in the United Kingdom last month by John Major, the prime minister (see *Nature* **375**, 265; 1995), to focus its funding on "generic" priorities, in a bid to improve links between basic and industrial research.

Under the new scheme, MOSA will allocate US$22 million this year to five generic priorities: computing, microelectronics, electro-optics — where Israel already controls 90 per cent of the world market in some areas — as well as biotechnology, and material sciences.

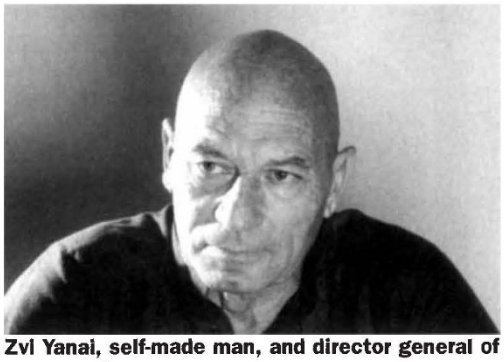
This sum will rise to US$30 million next year, and US$40 million the year after, and the number of priorities will be increased to include, for example, applied mathematics, environmental studies, water resources, pollution, social studies, or life sciences.

The move represents a bid by MOSA to use its funds more effectively. Although substantial, they account for only around 10 per cent of the country's total spending on research. MOSA previously took the politically expedient route of allocating money to research institutes to spend as they pleased, says Zvi Yanai,

director general at the ministry.

"We spread our resources too thinly, and when you spread thin you get zero", he says. MOSA will now award fewer grants, but will increase the amount of each individual grant from around US$50,000 to US$500,000, according to Leah Boehm, chief scientist at the ministry. "We are forcing scientists to think big, and to collaborate; we want to see a critical mass."

MOSA's overall aim is to support research that is more narrowly focused than basic research, but either too new, generic, high-risk or long-term to obtain support from the ministry of industry and trade (MIT), which subsidizes industrial research.



Zvi Yanai, self-made man, and director general of science ministry.

Basic research in Israel is mainly supported by the Council for Higher Education (CHE), a 25-member commission chaired by the minister of education, whose powerful six-man planning and grants committee proposes and allocates the national budget for higher education and research. CHE has a total annual budget of around US$1 billion

Industrial research is supported by the chief scientist at the ministry of industry and trade (MIT), who has a budget this year of US$450 million. MIT spending carries more weight than that of CHE, because most goes directly to research, whereas around 80 per cent of CHE's budget goes on salaries and overheads.

Moderate investment by MOSA could have "extraordinary leveraging power", by inserting an intermediate layer of generic research between the areas of basic and industrial research already supported by either of these two funding giants, claims Yanai. But such strategic research should not be at the expense of basic research, he adds.

Yanai points out that similar generic investment in defence — prompted by the French arms embargo imposed after the Six-Day War in 1967 — created Israel's electronics industry, which now accounts for more than half of Israel's exports. Given that the defence budget for strategic research and development has fallen by half over the past decade, Yanai argues that now is the time to develop a new strategy aimed at developing and exploiting new technologies.

This task cannot be left to industry, argues Itzchak Parnas, the head of the High Committee for Strategic Planning, which was set up last year to administer the new programme. Because MIT is allowed to fund only projects that private companies themselves invest in, industrial research has become too orientated towards existing industries, he argues. "If MIT had had this restriction 20 years ago, we would have invested in textiles not electronics."

Leah Boehm: as chief scientist at the science ministry, she has a satellite view of the country's research.

Indeed, priorities are decided by Parnas's committee — which is made up of 13 industrialists, scientists and government officials — on the basis of Israel's strengths in these areas, their market potential, and whether technologies could be economically developed either by using existing industries or by creating new ones.

As evidence of the need for such a strategy, Parnas points out that while Israel has a strong science base in molecular biology, it lacks a "single excellent centre" for either protein microsequencing or the production of transgenic animals — including knock-out mice — and plants. "We will now build such centres", he asserts, "and fund them at the same level as in the US or Japan."

MOSA's initiative has been welcomed by Haim Harari, the president of the Weizmann Institute, who says that identifying priorities and funding them fully is the ministry's job. "Whether or not they choose the best priorities doesn't matter so much", he says, "but spreading money too thin is only a waste of money. If in this way they get extra money for research from the government, that's fine."

Indeed, while one researcher is critical of the scheme, which he says "puts all the ministry's eggs in one basket", many seem either enthusiastic or indifferent. One reason is that few rely completely, if at all, on MOSA for research funding, but more on international foundations.

One leading industrialist argues, however, that the scheme only confirms that the Israeli government's industrial policy still relies too much on "technology push", and not enough on market demand. The search for commercially successful technologies should be left to profit-seeking investors, he argues, not to government officials. □

Change at the top

THE decision by the ministry of science and arts (MOSA) to concentrate its funding on a few "strategic priorities" (see above) is due to a change of management at the ministry, and in particular, the arrival over the past two years of an energetic 'gang of four', who share firm convictions about the role it should play in shaping the country's research.

The minister herself, Shulamit Aloni, is the founder and leader of Meretz, a progressive-liberal party that is part of the ruling Labor coalition government. She is a founder of the Israel Consumer Rights Council, and an author on civic issues raised by religion, education and women's rights, and arts were included in the ministerial portfolio at her insistence, according to observers.

But the driving force behind the ministry's new policies is its director general, Zvi Yanai, a self-made man with little formal education, who established IBM Israel's corporate communications department in 1970, and headed it for the next two decades.

The chief scientist, Leah Boehm, was appointed a few months ago. Despite being responsible for international foundations, policies on immigration and scientific cooperation with neighbouring Arab states, she still finds time — almost — to spend one day a week in her electro-optical laboratory at the Israel Atomic Energy Commission's centre at Soreq, near Rehovot.

Itzchak Parnas heads the ministry's high committee for strategic research, which was created last year to administer the new strategic programme. Parnas, who still works as a neurobiologist at Hebrew University in Jerusalem, also chairs the National Council for Research and Development, a forerunner of MOSA, which is made up scientists, engineers and industrialists, and now acts as an advisory body to the ministry. □

Weizmann thinks big

"WEIZMANN is people-driven. If we have a top-notch person in an important field we will invest enough to be the best, if we don't, we won't invest, no matter how important the area is." This is how Haim Harari, president of the Weizmann Institute in Rehovot, Israel, describes the institute's research philosophy.

Harari, who is a leading particle physicist — he coined the terms 'top' and 'bottom' quarks in 1975, in a paper proposing the theoretical need for their existence — explains that part of the thinking behind this philosophy is the desire to counter the "main disease of Israeli science", namely the tendency to spread resources thinly, instead of concentrating them in a smaller number of larger projects.

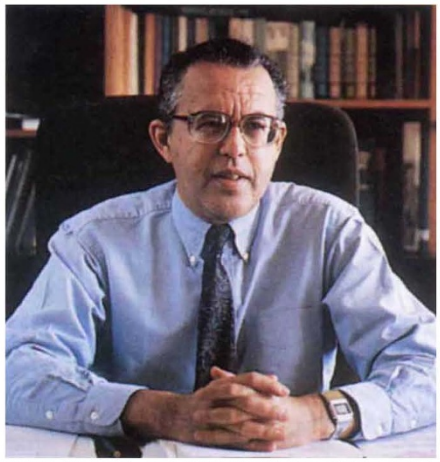
Evidence of the Weizmann's investment strategy dot the 1.2 square-kilometre campus of lawns and subtropical gardens, kept green by a computer-controlled irrigation system — a US$10-million heavy-ion accelerator built in the 1970s; a US$15 million solar energy tower erected eight years ago and a US$16-million nanotechnology centre constructed in 1990. A big brain-research centre is also being built. "No university in Israel has projects of similar scale", boasts Harari.

"In some areas, unless you invest enough, you needn't bother", says Harari. To build the nanotechnology centre, for example, the institute had the option of investing either US$4–$5 million or US$16 million. The first choice would have been the easiest, but would "at best have duplicated work being done elsewhere".

The second option was a "risk and a gamble", says Harari, in particular because the US$16-million funds would support "one brilliant person". "You have to make hard choices," he says, "and sometimes when you gamble you lose." Taking such choices is also the "best way to make enemies internally," he adds.

Indeed, the institute is unashamedly

Weizmann Institute, with Koffler accelerator of the Canadian Centre of Nuclear Physics in the background.



Haim Harari, president of the Weizmann institute.

élitist. "You don't become a good scientist by democracy, you are either at the front or get out", says Michael Sela, a renowned immunologist who was president of the Weizmann from 1975 to 1985. "There is nothing worse than being a mediocre scientist." Similarly, Harari claims that the institute abandoned research in high-temperature conductivity because "we didn't have a star".

But if the Weizmann has a superiority complex it is understandable. It produces some of the brightest stars in disciplines ranging from immunology to artificial intelligence. It is also continuing a tradition of vision and change inherited from its founder and first president, Chaim Weizmann, who later became Israel's first president.

Weizmann, a Russian-born chemist, believed that Israel's self-determination and self-sufficiency depended on linking science to Zionism, given that Israel badly lacked natural resources on which to build an economy. In 1933 — 15 years before the state of Israel was created — he founded in Rehovot the Daniel Sieff Research Institute, named after the son of Israel Sieff, a member of the family that owns the British Marks and Spencer chain of department stores.

At the time, Rehovot was only a small agricultural community in the British Mandate of Palestine. The Jewish population of Palestine numbered fewer than 400,000, and industry and commerce was almost non-existent. Weizmann's oasis of learning gave priority to agricultural and medical research relevant to local needs.

Expansion of the institute began in 1944, when, at a party organized in New York to celebrate Weizmann's 70th birthday, he was asked by his wealthy friends what he would like as a present. "I need nothing for myself", he replied, "but if you wish, do something for the expansion of the institute." An international scientific committee was formed shortly after, and the multidisciplinary Weizmann Institute, with more than 60 laboratories, was opened in 1949.

Today, the institute has 1,500 staff, more than three-quarters of whom are scientists, engineers or technicians, including 200 tenured professors — between five and ten new ones are recruited annually. Since 1988, eight departments have been closed, six new ones opened, and two created by merging existing departments. "Research institutes thrive on change", says Harari.

Last year, its budget amounted to almost 350 million shekels, 40 per cent of which came from the government, almost one-third from donations, and one-third from research grants and contracts. Although spending on new facilities continues to outpace the renewed growth in available funds, the Weizmann has overcome the financial difficulties it experienced in the 1980s and has managed to balance its budget for each of the past four years. □

Israel plugs into EU research

ISRAEL is to sign a broad cooperative agreement with the European Union (EU) under which it will become eligible to compete within the EU's five-year Framework research programmes.

Because subscriptions are based on gross national product (GNP), Israel will pay just US$30 million annually to take part in a programme that has a budget of ECU12.3 billion for the next five years. "We will pay according to GNP, but will win according to proposals. We therefore will do well", says one researcher confidently.

One official at the European Commission admits that Israel will be a "formidable competitor" within the programme, given its strong science base, its large existing network of international collaborations and its familiarity with seeking funds from organizations abroad.

Agreement between the EU and Israel was expected to have been reached several weeks ago, but has been delayed because of wider negotiations over trade issues. The ministry of industry and trade has also been seeking concessions from the commission to allow Israeli officials to sit on the committees that decide what funds are awarded and to whom. Israel may consequently miss the deadline for submitting some applications within the fourth Framework programme which runs from 1995 to 1999, says one researcher.

Joining Framework will "make a big difference to us", says Emanuel Marom, vice president and dean for research at Tel Aviv University. Similarly, the Weizmann Institute, which has just opened an EU liaison office in Brussels, "wholeheartedly" welcomed the move. □

Schools face science overhaul

ISRAEL is to embark on an ambitious scheme, costing several hundred million US dollars, aimed at improving science and technology education throughout the country, following recommendations made last year by a review committee — the Superior Committee on Science, Mathematics and Technology Education — appointed in 1990 by Zevulon Hammer, the minister of education.

The recommendations of the committee — which was chaired by Haim Harari, president of the Weizmann Institute — are contained in a report — entitled *Tomorrow 1998*, 1998 being the 50th anniversary of the foundation of the state of Israel. The report calls for the construction of new teaching centres, retraining of teachers, redesigning of teaching materials and a complete reorganization of school syllabuses.

It says, for example, that a national programme should be established to improve studies in mathematics, the natural sciences and technology throughout the education system. These areas should also become a required part of the syllabus from preschool to high school, it recommends.

In a time of rapid technology change, the report argues that teaching of basic disciplines has become "particularly crucial". It identifies more mathematics teaching at all age-levels as a priority.

Laboratory experiments should be integrated throughout such courses, say the report, even if this requires extensive building of new facilities. Similarly, computing should be introduced throughout the school and teacher training systems, it says. The cost of the entire scheme is estimated at 300 million shekels annually over the first few years.

"We are now making a big effort to implement the report's recommendations, says Benjamin Geiger, dean of the Feinberg Graduate School at the Weizmann Institute, whose science teaching department has itself been involved in developing science curricula for Israeli high schools for almost thirty years. □

Weed-killing at Weizmann

AGREEING to contribute an article to a multi-author treatise can end in tears. The publisher may be so obscure that its proof-readers may be the only people to read the text. Or a polite note may arrive, invariably after two years of silence, apologizing for the publisher being made bankrupt, and the book being shelved.

Jonathan Gressel.

But Jonathan Gressel, from the Weizmann Institute's department of plant genetics, will not regret contributing an article to a book, published in the United Kingdom, outlining a potential control strategy for the parasitic weeds, broomrape and witchweed.

A few weeks after the book was published, he received an invitation to a meeting with the Egyptian minister of agriculture, a professor of plant physiology and horticulture, and also Egypt's vice-prime minister. The outcome was a trilateral Egypt–USA–Israel programme, worth US$3 million over four years.

Broomrape (*Orobanches* spp) and witchweed (*Striga* spp) are parasitic flowering plants that develop underground in the roots of the host plant. The parasite completes its life cycle by sending up a flowering shoot which "basically tells the plant 'I screwed you," says Gressel.

In Africa, witchweed is estimated to infest 21 million hectares of grain-producing land, and cause 4.1 million tonnes of grain loss. Broomrape threatens 16 million hectares of cultivated land in the Mediterranean and West Asia, and according to Gressel, has caused Egypt to go from a grain exporter to a grain importer. The yields of infected plants are 30 to 70 per cent that of uninfected plants. "Looking at it another way, killing the parasite would double yields," says Gressel.

Given that no herbicides are available to kill the parasites selectively, chopping off flower stalks as soon as they appear remains the best means of control . The problem is that the parasites can lie dormant in the soil for up to ten years.

Gressel and his colleagues have been pursuing an alternative control strategy, aimed at producing crops resistant to particular herbicides. Treat the crop with the herbicide, and you should eliminate the parasite while leaving the crop plants untouched.

In designing a system, the group opted for a systemic herbicide that would be transported, like a sugar, through the plant's vascular system and reach the parasite in its roots. Directly applying herbicides to the underground parasite was considered impracticable.

This ruled out engineering the plants with metabolic resistance, which confers on the plant the ability to degrade the herbicide to non-toxic products, as most of the herbicide would be metabolized before it ever reached the roots. Instead, the researchers engineered the plant with target-site resistance, which involves modifying the plant enzyme targeted by the herbicide so that it no longer binds the herbicide.

By using three sorts of target-site resistances together, they controlled the broomrape parasite (see *Nature* **374**, 220; 1995). The doubling in the yields of crop plants obtained as a result would more than offset the cost of transgenic seed and herbicide, says Gressel, who also points out that the approach should be used only with crops that do not interbreed with related weeds in the same locality.

But transgenic plants will provide only a stopgap. Each flower stalk produces 70,000–100,000 seeds, and the consequent high mutation rate means that it rapidly develops resistance to herbicides. Using computer models of resistance, the group has devised a management strategy which predicts that leaving 5 per cent of plants in the field susceptible to the weeds should slow the development of resistance from three years to between seven and ten.

Meanwhile, Gressel is studying biological control as a potentially more permanent solution. To do so he identifies healthy plants in infested fields, and isolates from them several hundred strains of fungi as candidates for mycoherbicides. The problem with mycoherbicides is that millions of spores need to be sprayed onto plants to overcome their defence systems and obtain infection. This is not economic, and to reduce the number of spores needed, Gressel is now carrying out basic research to find ways of disarming the plants' defences. □

Space on a shekel

NINETY-EIGHT per cent of Israelis write backwards, and the country's space agency is no exception. Whereas everybody else launches towards the east to hitch a ride on the eastward rotation of the Earth, Israel launches towards the west to avoid violating Arab airspace, and to ensure that launcher stages fall into the Mediterranean, and not Saddam's backyard.

Israel joined the small group of nations that build and launch satellites in 1988, when it put into orbit the 156-kg experimental satellite Ofeq-1. In 1990, it launched a clone, Ofeq-2, and earlier this year a second generation platform, Ofeq-3, widely thought to carry remote sensing equipment for spying.

The lightweight Ofeq platform is designed to be suitable for various scien-

tific and commercial missions, and is part of Israel's effort to develop space capabilities, and boost the competitiveness of its industries in international markets.

The launches are also a personal success for Aby Har-Even, director-general of the Israel Space Agency (ISA) since January, who headed the development of Israel's solid-fuel three-stage Shavit launcher. Har-Even joined the agency from Israel Aircraft Industries (IAI) after retiring from the army in 1979.

His agency, a five-man outfit located in the northern outskirts of Tel Aviv near the city's university campus, manages Israel's small but growing space programme. It controls a budget of only a few million dollars annually itself, but both proposes national priorities to the government, which spends US$20–$30 million on space every year, and coordinates approved projects.

ISA was created in 1983 from the National Committee for Space Research, set up by the Israel Academy of Sciences and Humanities. Although closely linked to the defence industries, it has focused on civilian goals, says Har-Even, because military links "complicate international collaboration".

Developing infrastructure for space activities in academic institutions and in the defence and electronics industries is ISA's main job, according to Har-Even. Indeed, some of Israel's most advanced space technologies are emerging from an unusual programme at the Asher Space Research Centre at the Technion Institute of Technology in Haifa.

Students there, with help from immigrant Russian scientists, have designed and built a sophisticated 50-kg satellite with a power consumption of just 20 watts. Techsat-1, as it is known, was developed for just US$3.5 million, as almost three-quarters of the equipment was donated by aerospace companies keen to develop new ideas.

The bargain Techsat-1 was lost in March, however, during an equally bargain, but failed, launch on a converted Russian SS-25 ballistic missile which was flying for the first time — the launch fee was just US$250,000. Har-Even puts a brave face on the failure, pointing out that the Techsat structures that have been built up remain. Meanwhile, the government this month agreed to fund a replacement, Techsat-2, while Har-Even has not ruled out using the Russian launcher again.

The solid-fuel Shavit launcher ascends.

The first satellite carried a simple camera that would have provided scientific and environmental data on forests, agriculture, coasts and urban areas. But El-Op Electro-optics, the Rehovot-based company that supplied the instrument, is hoping to fly a multispectral camera on Techsat-2, which could be used in addition for geological research and monitoring of water pollution.

ISA is also supporting TAUVEX (Tel Aviv University Ultra-violet Explorer), a US$10-million cluster of three ultraviolet telescopes, which will be flown on the Russian-built Spectrum Roentgen-Gamma (SRG) international space observatory, scheduled to be launched by Russia next year, and which will also carry instruments from France, Italy, Denmark, Switzerland, the United States and the United Kingdom.

The future of Israel's fledgling space programme now lies in commercial exploitation and greater international collaboration, says Har-Even. Economic factors now drive "80 per cent" of the space programme, he says. The United States, for example, has agreed that Israel's Shavit can compete with the small Pegasus launcher in its domestic civilian market, provided half the industrial returns go to US companies.

Israel also plans to launch the first of two geostationary telecommunications satellites this year, as part of its main supposedly private venture, the US$190-million Afro-Mediterranean Orbital System (AMOS), in which the European companies Alcatel Espace and Deutsche Aerospace have also invested.

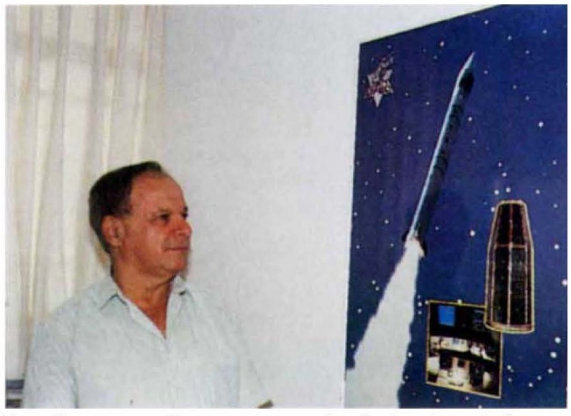
But old habits die hard, and the Israeli ministry of finance is said to have asked for subsidies of US$100 million for AMOS as part of its plan to support the loss-making state-owned company Israel Aircraft Industries. Many also remain sceptical of AMOS's commercial viability in the Middle East television market, where many already subscribe to cable, or other satellite networks.

ISA's international cooperation is focusing on remote sensing, and last year the agency signed a US$1-million three-year deal with the French space agency CNES covering research, data collection and technology. One result is the launch of the YAHEL programme, a Hebrew acronym for the use of satellite imagery in remote sensing for geological, agricultural and hydrological applications, including measurement of ground salinity,

The deal has been soured somewhat, however, by a decision by SPOT-Image, the company that supplies French satellite images, not to wait for ISA programmes, but to authorize El-Op to provide data from SPOT satellites, whereas the International Centre for Technological Forecasting and Analysis at Tel Aviv University had previously been the exclusive distributor of SPOT images received by ISA's ground station.

ISA also intends to build a ground station to receive images from the ERS satellites operated by the European Space Agency (ESA). It is also collaborating with the Dutch space agency, under an ESA programme, SLOSHSAT. The experiment will study sloshing — which has apparently become a problem with the use of bigger fuel tanks in satellites — in a tank of water launched to 100 km, and juggled around by Israeli nitrogen boosters.

ISA's ultimate ambition is to become an associate member of ESA, says Har-Even, although discussions are at an "early stage". "We want to really cooperate", he says, pointing out that Israel could provide ESA with expertise in its proposed small satellite programmes. Joining ESA might also enable Israel to avoid launching towards the west — which reduces payload capacity by half — by swapping its launchpad at the Palmachin military base near Tel Aviv for ESA's facilities in Kourou, French Guiana. □



Aby Har-Even, director general of the Israel Space Agency.

University on the up

ROCK music thumped around the 220-acre campus of Tel Aviv University (TAU) last month as students celebrated the end-of-year campus party that traditionally precedes the exams. Spirits were lower this time last year, when exams ran into the summer vacation, following a 77-day nationwide strike by academics over pay — TAU narrowly avoided losing an entire academic year because of the strike.

TAU, which is in the northern outskirts of Tel Aviv, was founded in 1956, and is now Israel's largest university. It has grown by a quarter over the past five years, and now employs 1,800 faculty and teaches 25,000 of Israel's 90,000 university students.

It has also recently opened the interdisciplinary Adams Super Centre for Brain Studies and the Porter Super Centre for Environmental and Ecological Studies. The university also houses two of the five centres of excellence set up last year by the Israel National Academy of Sciences — in astronomy and superconductivity. TAU boasts the only astronomical observatory in the Middle East.

TAU is also cooperating with the Weizmann Institute and Hebrew University to build two genome centres, one in genetic diversity and the other in bioinformatics. Its main interests are genetic diseases that particularly affect Jewish populations, such as Gaucher's and Tay-Sachs. The university also holds a joint patent with Germany's Max Planck Institute on transgenic herbicide-resistant wheat.

Two-thirds of the university's budget comes from the Planning and Grants Committee (PGC). The US$3 million set aside for research within the PGC grant was cancelled last year, however, to help pay for the wage settlements negotiated after the staff strike. A further quarter of TAU's budget comes from tuition fees, and the remainder from grants.

Research funds are scarce, says Emanuel Marom, vice president and dean for research and development at the university. TAU cannot afford large research projects such as those at the Weizmann or Technion, he says, and most researchers must make do with initial funding of US$50,000–$100,000.

TAU is also poorer than Hebrew University in Jerusalem, partly because it is younger and lacks the latter's large endowment, and partly because it needs to cover all disciplines, according to Marom, who adds that "we are growing fast, and catching up". □

An aerial view of theTel Aviv University campus, on the outskirts of the city.

A student at Tel Aviv University campus party selling student loans. As most Israelis are in the army from the age of 18 to 20, students tend to be older than their counterparts elsewhere.

War and peace

HEBREW University is one of the three academic institutes that were established by Zionists long before the state of Israel was itself created in 1948. The university opened in 1925 at the Mount Scopus Campus to the north of the Old City of Jerusalem, with 141 students, 33 faculty and research programmes in chemistry, microbiology and Jewish studies.

Werner Braun

IMAGE UNAVAILABLE FOR COPYRIGHT REASONS

Hanoch Gutfreund, president of Hebrew University.

By 1947, the university had added departments in medicine, science, humanities, education and agriculture (in Rehovot), and had 200 staff and over 1,000 students. But the following year, the Mount Scopus Campus was cut off from the Israeli-held parts of Jerusalem during fighting in the war of independence.

After operating from temporary facilities throughout the city for five years, the university built a new campus at Givat-Ram in the centre of the city, followed a few years later by a medical school campus at Ein Kerem in south-west Jerusalem.

After Israel recaptured Mount Scopus during the Six-Day War, the university rebuilt and expanded its previous campus there, and in 1981 this became its main campus again. Today, the university has over 23,000 full-time and 14,000 part-time students. Hebrew University also claims to carry out over 40 per cent of Israel's civilian research.

Last month, Hebrew University also agreed to set up an International School for Molecular Biology and Microbiology for Peace in association with the United Nations Educational Scientific and Cultural Organization (UNESCO). The school will bring together scientists from throughout the Middle East to help tackle regional health and environmental problems. □

Science strikes back

THOUSANDS of school students and their teachers in Jerusalem are now using fully-equipped modern research laboratories in chemistry, physics, biology and computing, as part of a new scheme aimed at encouraging children to pursue science courses.

The Belmonte Science Laboratory Centre for Youth, as it is known, is the brainchild of Itzhak Parnas, the chairman of the High Committee for Strategic Planning (page 722), who is also a neurobiologist at Hebrew University. The centre, which was opened in 1990, is located at the university's Givat Ram campus in downtown Jerusalem.

Itzhak Parnas, catching them young.

The idea is to address the lack of good laboratory facilities in most high schools by creating one well-funded and maintained centre, serving all the schools in a given area — each class attends the centre several times per term. Students are taught by their own teachers, who themselves have been trained in the laboratory beforehand by PhD students from Hebrew University, who also supervise the laboratory experiments.

The centre's purpose is both to bring teachers up to date with developments and techniques in scientific research, and to encourage more pupils to pursue science at school, and afterwards at university. "I don't think that all kids select humanities because they want to, it's partly because we don't show them the glory of science," says Parnas, who directs the centre.

At present, however, the centre is only open to 11th and 12th graders — which corresponds to the last two years of school — whereas the decision to take science courses at this level is taken the year previously, in 10th grade. Parnas plans to expand the centre, however, to open it to 10th graders. Meanwhile, plans are also under way to create 18 similar centres throughout the country. □

Swords into ploughshares

ISRAEL'S ministry of industry and trade (MIT) will this year pay out more than US$450 million in subsidies for industrial research,US$150 million more than last year, when it sponsored more than 1,300 programmes and 800 companies. "The rate of participation is enormous", says Shuki Gleitman, MIT's chief scientist, "I would use the word 'boom'".

MIT provides companies with up to half the costs of research projects, most of which are near-market. If a project succeeds, the company must reimburse the sum in royalties. If it fails, it pays back nothing. This year MIT will collect US$60 million in royalties, according to Gleitman.

Another programme, MAGNET, is aimed at encouraging companies to collaborate on 'pre-competitive' generic research. The programme, which has been running for just over two years, provides companies with up to two-thirds of the costs of a project. To qualify for funding, consortia must also include at least one academic institution.

Israel exported US$11.5 billion of goods last year, and more than half of these were produced by technology-based companies. Thirty years ago half Israel's exports were agricultural produce.

The electronics industry accounts for most technology exports and almost three-quarters of industrial research and development in Israel. The industry was created from scratch by massive government investment in the defence industries, following the decision by France to impose an arms embargo after the Six-Day War in 1967.

While sales of military equipment have remained flat over the past few years, those of civilian electronic goods have been increasing by around 20 per cent annually. Much of Israel's defence industry focuses on software and telecommunications equipment which have applications in civilian sectors. Last year civilian goods represented four-fifths of electronic exports compared with just half in 1988. □

Biotech drugs comes to market

ISRAEL'S drug industry seems poised for a boom. Beta-interferon, a drug that slows the progression of multiple sclerosis, and which is produced by Interpharm, is expected to be approved in Europe next year, and to reach annual sales of US$100 million by the end of the decade.

Another multiple sclerosis drug, called Copaxone, being developed by Teva pharmaceuticals, is expected to reach the market next year, and analysts predict it will reach annual sales of US$388 million by 1998. A genetically-engineered version of human growth hormone produced by Bio-Technology General (BTG) has also been approved in the United States.

Interpharm was created in 1979 to mass produce interferon-β for clinical trials. Ironically for Israel, the initial interferon is produced from foreskin fibroblasts. Interpharm, whose plant is near the Weizmann Institute in Rehovot, also teamed up with the Swiss company, Ares Serono, which now holds a majority stake in the Israeli company.

The technology for producing recombinant interferon-β was developed by Michel Revel, a researcher at the Weizmann Institute, who is also a director of the company. Revel was the first to produce beta-interferon in Chinese kidney hamster ovary cells (CHO), which yield a glycosylated molecule that is better tolerated by patients than interferon-β produced by conventional systems that using *E. coli*.

Interpharm's interferon-β has also been shown in early clinical trials to be an effective treatment for colon cancer (in combination with 5-fluorouracil) and small-celled lung cancer. "These are new applications that show the drug has a big future", says Revel. The company also produces interleukin-6, which might be used both to increase platelet counts in patients undergoing chemotherapy, and to prevent metastases of non-immunogenic tumours.

Two of BTG's founders also joined the company from the Weizmann Institute, where one had been a student of Revel's. Another of Revel's students founded Orgenics, a diagnostics firm renowned in particular for its HIV test kits.

Teva's multiple sclerosis drug Copaxone — which has been found to reduce the rate of relapse in patients — is also the product of research at the Weizmann Institute. The drug is the outcome of 25 years of research at the institute into copolymer-1 (COP-1), a synthetic protein designed to mimic basic protein, a major component of the myelin sheath, the tissue damaged in the exacerbating/remitting (ER) stage of the disease. COP-1 was first proposed by Michel Sela and Ruth Amon, both from the institute, as a tool to

study how T-cells recognize and destroy myelin.

But while Weizmann institute research is driving some of Israel's most successful biotechnology companies, the attitude of academics at the institute and Israeli universities is discouraging commercial development of basic research, according to some researchers. In particular, scientists who become involved in commercialising their research are alleged to suffer diminished prospects for promotion. "It's academic suicide", says one researcher.

Haim Harari, the president of the Weizmann, admits that this is a problem. "I support technology transfer", he says, "but those involved do pay sometimes in terms of their careers." The faculty committees that decide promotions often frown on industrial ties, he says: "there is a contradiction between the policy of the management and that of the majority of the professors, who democratically elect the committees."

While finding venture capital for biotechnology start-ups is fairly easy in Israel, some observers are also concerned that such start-ups lack the regulatory and marketing expertise to be able to survive in the international market. "We have had 60 start-ups in biotech over the last few years, but most will not make it,", predicts one scientist. Israeli companies need to hook themselves onto multinationals, argues Revel, if they are to sell internationally. "Growing big by yourself is the only alternative", he says, "and this takes too long." □

In the shadow of Ben Gurion

TWENTY-thousand chickens suffocated last month, as temperatures climbed into the upper-forties during Israel's worst heat wave for 40 years. But temperatures inside the main building of the Jacob Blaustein Institute for Desert Research in Sede Boker, in the Negev Desert, nonetheless remained comfortable — without any assistance from air-conditioning.

The building provides a balanced temperature, day and night, by exploiting appropriate architectural design concepts, many of which were known to ancient desert settlers, but have been forgotten in the design of many modern buildings. Embedding a massive stone column, or 'heat sink', in the centre of a building, for example, dampens excessive temperature fluctuations by absorbing and storing large amounts of heat.

Such architectural designs are also symbolic of a profound shift in the goals of Israeli desert research, away from conquering the harsh environment, and towards living with the conditions it imposes. This shift is important, because desert research in Israel, besides its academic interest, is a key to the country's future.

The reason is simply explained. The desert area south of Beersheva account for two-thirds of Israel's surface, but less than a tenth of its population. The population density in the rest of Israel exceeds 500 per square kilometre, or half as high again as that of Japan or Holland, and if population growth continues at its present rate, it will be 2.5 times higher than that of either country within 30 years. These people will have to go somewhere, and the desert is one of the few areas available.

Inscription by David Ben-Gurion, Israel's first prime minister, celebrates the creation of the Desert Centre.

David Ben-Gurion, Israel's first prime minister, recognized the imperative of exploiting the desert, from the moment of Israel's creation. Indeed, he set an example by moving to the kibbutz at Sede Boker in 1953 at the age of 67, where he lived with few possessions, apart from his vast collection of books.

The research centre, which was established in 1974, is a faculty of the university that is named after him, the Ben-Gurion University in Beersheva, which was itself founded in 1969.

Ben-Gurion and his wife are buried on a ridge above the research centre, overlooking both the awesome canyons of the Zin Valley (shown on page 729), and the shops and houses of the Midreshed community which houses both Ben-Gurion's archives, and the 150 or so families who work either at the centre, or at the community's renowned boarding school.

But while Ben-Gurion's Zionist ideals of creating an "oasis of learning, an Oxford, in the desert" are perpetuated by the community, most of whose residents are either researchers or teachers — around 40 of whom religiously attend the weekly 'journal club' — his vision of making the Negev "bloom" have never really materialized.

"We've had to twist Ben-Gurion's philosophy," says Berry Pinshow a zoologist at the centre, whose wife is the curator of the Ben Gurion archives at Sede Boker. "He wanted to fight the desert, but our philosophy is 'wise settlement' of the desert."

Earlier attitudes are captured by a zealous Zionist folk song, which roughly translates as "Oh dear homeland, we will cover you in roads and concrete". The homeland will be happy to hear that

Closed culture of *Spirulina*.

Science in the sand

BERRY Pinshow, a zoologist, is one of the many fundamental researchers at the Jacob Blaustein Research Centre in Sede Boker who study the desert for its own sake. Indeed, like many at Sede Boker he is a desert enthusiast: "I love living in the desert, and the weather is terrific," he says.

His early career took an unexpected turn, however, when he obtained a postdoctoral position with a research group at Duke University in the United States that was renowned for its work on deserts. On arriving, he discovered that the laboratory had long ceased work on desert animals, andhe ended up working in Ant arctica for several years on the ecology of emperor penguins.

One area in which the now thawed-out Pinshow works is on the physiology of migrating birds. Israel is a good place for such studies as between one-tenth and one-fifth of all birds migrating to Africa pass over the country, which lies along one of the three main north–south migrating routes.

In particular, Pinshow is studying the role of water balance and plasma volume during migration. Apart from field studies, he is also using Tipler homing pigeons — which can fly for up to five hours at speeds of up to 60 km an hour — as an experimental model. The birds have a genetic defect that makes them fly in large circles, and they can be trained to return to the laboratory on hearing a loud whistle. □

today's visionaries prefer to adorn her with solar energy panels, harnessing the desert's ample sunshine, integrated fruit and fish farms using the plentiful, but brackish, water that has accumulated in aquifers below the Negev, and plants engineered to flourish in her spartan soil.

Indeed, while efforts to produce more fresh water may someday provide sufficient amounts for large-scale irrigation of the desert, Samuel Applebaum is now concentrating on developing integrated fish farms at the centre that could exploit the enormous quantities of warm 'fossil' water lying a few hundred metres below the Negev.

This pollution-free water, he points out, is ideal for cultivating highly productive species such as *Tilapia*, catfish and eels, while the excrement-rich waste water can later be used to irrigate salt-resistant crops such as tomatoes and melons.

Negev Desert, from the research centre.

Because *Tilapia* has scales and fins — and therefore qualifies as kosher — it sells well domestically, where it is known as St Peter's fish. Eels, which are cultured in Sede Boker at such high densities (up to 200 kg m^{-3}) that it is difficult to see the water for flesh, are definitely not Kosher, and are exported as delicacies. Ornamental fish, which are also farmed at Sede Boker, also account for $9 billion of Israel's annual exports.

Avigad Vonshak is also pursuing aquaculture, but this time of algae. Earlier ideas of producing algae for cheap protein have been abandoned, however, and Vonshak is exploring genetic techniques and closed-cultivation systems to grow algae which are either expensive themselves — such as *Spirulina*, which sells as a health food — or can be used to produce high-value chemicals.

Solar panels amid the domes, Jerusalem.

Avi Golan is working on the biochemistry of another cash crop, this time pistachio trees, which can flourish with almost no water. Golan has recently won a grant from the European Union, along with colleagues in Egypt and Belgium, to establish a germplasm bank and breeding programme for the tree. World demand for pistachio nuts outstrips supply.

Golan is also carrying out an ethnobotanical study of desert plants to find compounds with properties of interest to the biotechnological industry. But his efforts to compile local folk knowledge of medicinal plants before this is lost have been frustrated by his discovery that even the eldest of Bedouin nomads now seem to prefer the local oasis pharmacy to traditional medicines.

But despite the diversity of desert research at the centre, which has an annual budget of US$10 million, one leaves Sede Boker with the uncomfortable impression that its vision of colonising the desert may, like that of Ben-Gurion's before, fall short of its ambitions.

A prototype high-technology greenhouse in which plants need only about 10 per cent of their normal water requirements — which was described in *Nature*'s 1987 survey of Israel (see *Nature* **327**, 583; 1987) — for example, remains just that, a prototype. Indeed, what the centre seems to lack are means of developing and commercializing the technologies it produces.

"Our impact is not as much as we would like it to be," admits Reuven Kopel, who manages the centre and is also responsible for development of the greenhouse. "Its a process of educating government agencies to provide more funding", he says philosophically, "and that takes time." "The problem", agrees Yair Zarmi, deputy director of the centre, "is that the research groups are too small, and lack the critical mass needed."

Indeed, Israel Dostrovsky, who leads solar energy research at the Weizmann Institute, says that while the desert centre has developed impressive solar power systems, "time is against it". The centre is "too small and too isolated", he says, predicting that the much larger investments made by the Weizmann in solar power will allow it to produce commercial-scale systems long before Sede Boker does. □

A prophet in his own land

ISRAEL could soon appear on satellite images as one long strip of aluminium foil. That is, if Israel Dostrovsky, who heads the solar energy programme at the Weizmann Institute, gets his way. Dostrovsky is convinced that Israel will one day "go solar".

Israeli law already requires all buildings more than six storeys high to be equipped with solar panels for water heating, a move that has reduced the national electricity bill by 3 per cent.

But Dostrovsky, a former president of the Weizmann Institute, has much bigger ideas. "We are talking about a national system, we are talking about replacing oil", he says. Indeed, what sets Dostrovsky's research apart from much other solar research is that it is aimed at overcoming the main bottlenecks to developing systems capable of supplying whole countries.

Operating such large systems would mean, for example, that the energy collected would have to stored and transported somehow. The obvious reason is that the sun does not shine at night — even in Israel, which averages more than 300 days of sunshine per year — or through clouds. Another is that while desert areas are the obvious site for the vast solar plants needed, these are far from population centres, where most electricity is consumed.

Another problem is that solar power installations are expensive, because they require large areas of collectors — a 1 m^2 collector can at best collect 1,000 kW per day. To compensate for this, conversion of the energy collected into electricity must be highly efficient.

Dostrovsky believes that high temperatures are the key to the problems of both storage and transport, and efficiency. Whereas most solar energy systems operate at low temperatures, the 64 parabolic mirrors and solar tower of the

Solar Tower, The Canadian Institute for Energy and Applied Research, at Weizmann.

US$15-million Central Receiver experimental facility at the Weizmann Institute (see below) can generate temperatures of up to 2,000 °C, although it usually is operated at around 1,000 °C.

To solve the problem of storage, Moshe Levy, another Weizmann scientist, has developed a catalytic process that uses solar heat to react methane with either steam or carbon dioxide at 900 °C to give a stable mixture of hydrogen and carbon monoxide (synthesis gas). This reaction is endothermic, and all the solar energy put in is contained in the synthesis gas.

This synthesis gas can be easily stored at high pressure and transported, and the energy recovered when needed simply by reversing the reaction using an appropriate catalyst — this also regenerates the starting products. The theoretical efficiency of the process is 100 per cent, and Levy has obtained efficiencies as high as 80 per cent in practice.

Dostrovsky says his group is now testing this regenerative system within a 0.5-MW solar power plant, and is negotiating to build a 10-MW plant. "It would be nice to build this in Israel," says Dostrovsky, "but we will go wherever the funding is."

The temperatures produced in the Weizmann system are also similar to, or higher than, those in industrial power cycles. Indeed, while conventional power stations burning fossil fuels, which operate at around 500 °C, are around 35 per cent efficient, the conversion of energy to electricity at 1,000 °C can in theory be as high as 60 per cent.

Such levels of efficiency are reached in the latest generations of power stations. These use a process that involves first driving hot (1,200 °C) compressed gas produced by combustion of fuel through a gas turbine — which works in much the same way as a jet engine — and then exhausting it through a conventional turbine at 500 °C, in what is known as a 'combined cycle' system.

Over the past five years, the Weizmann group — in collaboration with the Israel Electric Corporation and Ormat Turbines — has been testing a 50-kW gas turbine system in which the hot compressed air used to drive the turbine is produced instead by first passing air through long ceramic tubes that are heated directly by solar radiation. The group also has plans to scale up to a 500-kW plant, although the development costs of anything larger would be prohibitive and would require commercial investment.

Dostrovsky says he is now "more optimistic" about the prospects for solar power. In particular, he predicts that Israel's growing thirst for water, rather than its demand for electricity, is making a national solar power system a more attractive proposition.

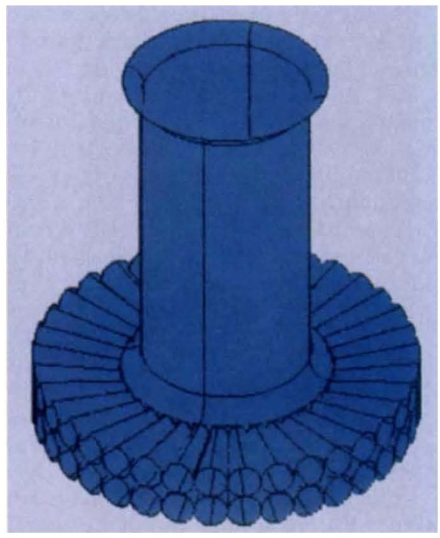
Desalination of sea water is the ultimate solution to the scarcity of water in the Middle East, argues Dostrovsky, but while the technology required is mature, desalination requires huge amounts of cheap energy to make it economically viable. Combined solar energy/desalination plants, producing both electricity and water will be the best solution, he predicts. □

Tower of Babel

In 1988, rain fell from a high cloud onto the desert city of Beersheva, cooling the warm and dry column of air below, and causing the colder air to collapse towards the cacti at high speed. The suddenly air-conditioned local airport suffered US$1 million of damage.

Researchers at the Technion Institute of Technology in Haifa are now trying to artificially create similar conditions to produce continuous wind, which could be converted into copious amounts of cheap electricity.

Both the plan and the physics are straightforward. Find a hot and dry district. Erect a hollow tower at least 1 km high, or around three times taller than the Eiffel Tower. Pump tonnes of sea water to the top, and atomize it. Evaporation should then cool the surrounding warm and dry air, and cause it to tumble down the tower at around 60 km per hour. Then, simply slot in a wind turbine at the bottom, and plug it into the national grid.



Schematic shape of energy towers.

The idea is not new — it was first proposed by Philip Carlson in the United States in 1975 — but little serious technological development was done until the Technion group took up the project 13 years ago. Over the past four years, the ministry of industry and trade has generously funded the project.

On paper, energy towers, as they are called, appear a solution to Israel's power needs, and indeed the world's, as in theory they could supply many times the current world energy needs, at a cost as low as 0.7 cents per kilowatt hour. Global circulation produces plenty of the hot air needed.

The political problem is that the same straightforward physics also predicts that the power of energy towers increases dramatically with the height and diameter of the chimney. While the government is said to be about to invest US$30 million in the building of a 50-MW 200-metre prototype, sceptics argue that this would test only the basic principles. Proving that the process is economic, they argue, will require gambling nothing less than US$650 million on the real thing, a chimney at least 900 metres high.

Deciding whether to take such a gamble is a political dilemma. Moreover, as any engineer knows, extrapolating energy towers directly from the drawing board to the building site is asking for unpredictable problems, on top of the predictable perils such as salt troubles in one's tower and turbines. Such snags could yet throw cold water on the cleverest economic calculations. □

War of the wells

Water supplies in the Middle East are like a blanket that is too small. If one country consumes more, less is available for its neighbours. Indeed, Avraham Sela, a political scientist at Hebrew University in Jerusalem, has argued that water could cause war in the region, in particular between Syria, Iraq and Turkey, who compete for the waters of the Tigris and the Euphrates.

Israel also competes with Syria and Jordan for water, while Gaza depends on Israel for its supplies. Middle Eastern countries met this month in Amman, Jordan, for the latest in a series of multilateral negotiations about water. Israelis, Palestinians and Jordanians are also considering drafting a 'water charter' among themselves to improve the manage-

Map showing alternative alignments for the Dead Sea project's canals.

ment of supplies.

The Sea of Galilee supplies one quarter of Israel's fresh water, and ground water the rest. But Israel's water consumption, 1.8 billion cubic metres (BCM) already outstrips its renewable freshwater resources, 1.5 BCM, the difference being made up, for example, by reusing treated waste water. Drinking water supplies are being threatened further by pollution of ground water.

To ease its water shortages, Israel is reassessing a proposal for an ambitious engineering project — The Dead Sea Hydro Project — that would involve constructing canals from the Red or Mediterranean Seas to the Dead Sea. The project, as originally envisaged, was aimed at exploiting the 400-metre difference in height between sea level and the Dead Sea, to produce electricity.

But the project, which was rejected by the energy ministry in 1986, has now been revived, with the major emphasis not on electricity production but on desalination. Its main aim is now to produce 0.8 BCM of water annually for Jordan and Israel using a hydrostatically powered reverse-osmosis desalination system.

The energy would be created by discharging 1.2 BCM of water in the Dead Sea annually, a volume equivalent to the sea's annual deficit. Three canal routes are currently being studied (see map). The total cost of the project is estimated at US$5–$7 billion, depending on the route, and would solve water problems in the region for 20 to 30 years. Referring to the proposals, Ezer Weizmann, Israel's president, has said that "a big project is needed to symbolize peace, and show that something is being done ". □

Cool crops

BEING a plant in a hot and arid area can be tough. Just when it breathes relief at having survived a heat wave and a long drought, along can come a period of particularly scorching sun, throwing it biochemistry into a spin, and causing the release of toxic oxygen molecules that damage and eventually destroy its photosynthetic apparatus.

Help for such sun-sensitive plants may be on its way. Ada Zamir's group at the Weizmann Institute, have recently worked out the mechanism by which the sturdy saltwater alga *Dunaliella*, the Land Rover of the algal world, survives scorching sunlight. The alga flourishes in the brackish marshes of the Sinai desert, and even in the Dead Sea.

Zamir's group have discovered a protein, known as Cbr, that *Dunaliella* synthesizes when its photosynthetic system is threatened by sunlight, and cloned the gene coding for it. It has also found evidence that the protein binds with the carotenoid pigment zeaxanthin, which is also formed under conditions of extreme sunlight — in a move which diverts excessive sunlight energy away from the photosynthetic apparatus.

The findings raise the possibility that weakling crops might be engineered into hardy desert survivors better able to resist the strong sunlight in such hot and arid areas. □

Nothing but "Perrier"

THE Dead Sea is already the lowest lake in the world — around 400 metres below sea level — and since 1960 its level has been dropping by 0.5 metres annually. The main cause is increased use of water from the Jordan river, which flows into the Dead Sea, while rain in the region only amounts to around 60 mm annually.

A dropping Dead Sea is bad news both for tourism and for the operation of the Jordanian and Israeli Dead Sea works. But the new salty shores that have been exposed as a result of the drop in water level have provided a unique opportunity to study the colonization of hostile environments.

Indeed, some desert plants have already invaded these shores, and become established. This in itself is fairly remarkable, given that the salt concentrations in the soil shore are three times those of ocean water, but what is even more surprising is the particular way in which the plants — such as species of *Sueda*, *Anabasis*, *Atriplex*, *Hamada* and *Tamarix* — have managed to survive.

An analysis of the isotopic composition of the water in the plants — carried out by Dan Yakir of the Weizmann Institute, and Yoseph Yechieli of the Geological Survey of Israel (see *Nature* **374**, 803; 1995) — showed that it differed from that of the salty soil water. Instead, the isotopic fingerprint matched that of the sporadic winter floods that flow into the area from the Judean hills.

This suggests that the plants are able to discriminate between the chemical differences in flood water and that of the surrounding salty soil. "Such a capacity", the researchers point out, "may be a prerequisite for successful invasion of highly stressful environments, allowing for the early onset of terrestrial biospheric activity".

Such experiments may come to an end, however, if a project aimed at exploiting the 400 metre difference between sea level and that of the Dead Sea to generate electricity (see figure) goes ahead. The plan which would involve constructing canals to allow water to flow from the Mediterranean or Red Seas into the Dead Sea would restore its historical level. □

Power in parallel

A SUPERCOMPUTER is the "first priority" on the shopping list of the ministry of science and arts (MOSA), according to Itzhak Parnas, the chairman of the ministry's High Committee for Strategic Planning. Israel has previously been prevented from buying one by a ban by the United States on the export of supercomputers, said to have been imposed because of Israel's refusal to sign the Nuclear Non-Proliferation Treaty.

But President Bill Clinton has now promised Yitzhak Rabin, Israel's prime minister, that he will lift the restriction, says Parnas, who adds that MOSA is coordinating the pooling of US$20 million from various Israeli organizations to buy the country's first machine. Responsibility for operating the machine will then be passed onto the Inter-University Centre for Computation.

Faced with the ban, however, Amnon Barak, a computer scientist at Hebrew University, has improvised and developed a powerful supercomputer substitute based on linking 28 Pentium PCs using a modified UNIX operating system. This parallel computing system, which cost just US$150,000 to build, distributes parallel tasks among the PCs, allowing them to carry out calculations simultaneously. In particular, the software he has developed ensures that all computers have the same load at all times. □

Fertile discussions

THE modern techniques of medically-assisted procreation pose a dilemma for orthodox Jews, because while they are concerned about the ethical issues these raise, they are keen to reconcile such technologies to their religious laws which oblige Jews to reproduce.

Indeed, fertility is a major issue for orthodox Jews. This is reflected in the fact that while obtaining a divorce is generally difficult under Jewish law, a man can divorce his wife if she does not produce offspring within ten years.

At a recent conference on bioethics at Tel Aviv University (TAU), it was disclosed that secret talks on medical issues, and in particular the treatment of infertility, have been going on for over two years between four leading rabbis of the 'Haredi' (ultra-orthodox) community, and scientists, philosophers and lawyers.

Lord Immaneul Jakobovits, who is a former chief rabbi of the British Commonwealth, an orthodox expert in Jewish medical ethics, and one of the main architects of British government policy in bioethics, described the talks themselves as a "historic event without precedence" and the TAU conference as a useful attempt to "bridge the divide" between the scientific and ultra-orthodox communities.

Jacobovits told the conference that orthodox Judaism supports new technologies which treat infertility, given that the decreasing size of the Jewish population threatened the long-term survival of the Jewish population. He also approved the use of surplus human embryos for scientific research.

Research in infertility is also the focus of the Male Fertility Clinic at Bar-Ilan University. But whereas fertility has often been mainly studied by gynaecologists, urologists and endocrinologists, Binyamin Bartoov, a researcher at the university, is trying to develop a research discipline dedicated to the study of sperm.

As well as gathering epidemiological data, his team is developing techniques such as cell manipulation and selection, to allow sperm production from males who were previously considered infertile. All of the research is supervised by the *halakhah,* the leading decision makers in Jewish law.

But bioethics is only the latest example of where orthodox Judaism and science can clash. Although Israel is not formally a theocracy, state structures conform to orthodox Judaism, and religious parties still hold considerable influence in the parliament, or Knesset, where no party has ever held a majority and horse trading to form coalition governments is the rule (see page 718).

Occasionally, this political situation does lead to major confrontations. Almost all the human skeletons from ancient populations which were previously housed at Israel's Antiquities Authority, for example, have recently been transferred to the Religious Affairs Ministry to eventually to be buried anonymously. Orthodox Jews had argued that research on such bones contradicted with Jewish laws forbidding the disturbance of Jewish graveyards.

But most potential conflicts between science and religion are sorted out amicably, as are many other conflicts between the law and modern everyday life. Lighting fires is prohibited on the Sabbath, for example, and ultra-orthodox consider this to include switching on domestic lighting. As a result, many homes are equipped with lighting systems which switch on automatically at dusk — some poorer households, which cannot afford the equipment make do in the dark.

Similarly, answering the telephone on the Sabbath is prohibited, because this is considered as "work" under Jewish law. This has resulted in the development of telephones which answer automatically, and place the caller on hold. As the connection is already established, picking up the handset does not then constitute work. □

Jurassic parchment

MAPPING the human genome depends on first breaking it up into manageable sized-chunks and then rearranging these chunks in the right order by identifying overlapping sequences. Geneticists in the United States and Israel are now using DNA techniques to solve another jigsaw — piecing together thousands of fragments from the Dead Sea Scrolls.

The scrolls, the oldest surviving copies of biblical texts, were discovered in 1947. Since then, around 15 of the scrolls have been translated, but analysing the remaining parchment is about as easy as making sense of a copy of *Nature* that has been fed through an office shredder, as it exists only as fragments — over 10,000 of them — in various states of decay.

The scrolls were written on animal skin, however, and still contain DNA, more than 2,000 years after they were written. Over the past year, researchers at the Hebrew University in Jerusalem and their colleagues at Brigham Young University in Utah, have been trying to piece together fragments by identifying which came from the same species, or even the same individual.

Most of the scraps of the scrolls seem to have been written on goatskin, but also on skin from sheep, ibix, or gazelles. Biblical scholars, have enthusiastically welcomed the research, because by showing which fragments belong together, it allows them to replace one enormous jigsaw with several smaller ones. □

The Bible enters the computer age

SCIENCE and religion are coming together at Bar-Ilan University in Ramat Gan, in a project that is combining computers and classical biblical scholarship to produce a definitive edition of the Bible, and its *massorah* and *targum* commentaries, known as the *Mikraot Gedelot.*

The original version was published by Ya'acov Ben-Haim in Venice in 1525, who brought the then modern printing technologies to bear on the various hand-written manuscripts available. The new work has been carried out by Menachem Cohen, who holds Bar-Ilan's Weiser Chair in Medieval Biblical Commentary, in cooperation with computer scientists.

The revised *Mikraot Gedelot* is based on the *Aleppo Codex*, which is considered to be the most accurate mediaeval text available, in terms of usage and spelling. The team has already published three of the 18 planned volumes, and a CD-ROM version is under way.

With comparison at the touch of a button of not only passages, but also sentences and words, academic study of the bible will never be the same again. The world's best selling book is moving into the world of multimedia.

It is appropriate that such a research project should be carried out at Bar-Ilan. The university, which this year celebrates its fiftieth anniversary, is mainly dedicated to Jewish studies. All students must take a minor in Jewish history, literature, ethics and culture.

Apart from Jewish studies, the university has four other faculties: natural sciences — which covers most area of science — social sciences, humanities and law. Between 1955 and this year, student numbers at Bar-Ilan University have grown from 56 to 19,510, and staff from 24 to 1,306. Over the next decade, the university plans to double the surface of its buildings in a 70-acre extension to the campus.

Another peculiar analysis of the Bible that has been pursued by computer studies is that of Moshe Zeldman, a mathematician and rabbi in Jerusalem. As evidence of the Bible's divine origin, Zeldman has claimed to show that groups of words hidden in the text relate to events that occurred long after it was written.

His system, which studies equidistant letter sequences (ELS). has been pursued by a group of US and Israeli mathematicians and Rabbis, in particular Eliyahu Rips of Hebrew University. One computer search, for example, found ELSs corresponding to the Hebrew transliterations of Hitler, Germany, and Auschwitz, in the passages of Genesis dealing with another Holocaust, Noah and the flood. Coincidence? □