"A square mile of pure science", runs the Livermore's own caption to this aerial view.

should be able to dream up ambitious programmes and have the engineering expertise available to build big.

For example, the heart of the inertial confinement fusion programme is a gigantic laser called NOVA. The idea is to generate and focus a beam powerful enough to crush atoms together.

And the aptly named MACHO project is part of a collaboration to hunt for dark matter, on the hypothesis that it consists of invisible 'brown dwarfs' in the haloes of galaxies such as our own (MACHO stands for MAssive Compact Halo Object). The brown dwarfs in the halo of the Milky Way would be detected from the lensing effects of their gravity fields on the brightness of stars in the Magellanic Clouds. Such events are likely to be extremely rare. The MACHO approach, therefore, is to measure the brightness of millions of stars at once, using the largest CCD cameras ever built, with the gigantic amounts of data processed by some of the fastest computers. MACHO has acquired more photometric data than have been gathered in the entire history of astronomy. And it's still only in its engineering phase.

Researchers on the Electron Beam Ion Trap (EBIT) can pluck electrons from atoms like berries from a bush. Work on the behaviour of highly ionized species (the most egregious is a helium-like uranium cation, U^{90+}) is adding a third dimension to the periodic table.

Livermore is the home of the DoE's contribution to the Human Genome Project. This seems strange, until one realizes that LLNL has (naturally) among the most powerful gene sequencing technology to be found anywhere. Indeed, biological research is a valuable spinoff from other areas of research here, notably the laser programme. LLNL has led the world in the handling of X rays. It is now possible to reflect and refract X rays (almost) as easily as visible light. Thanks to X-ray lithography, it is now possible to cram a gigabit of memory onto one chip. Thanks to X-ray holography and laser microscopy, it is (or soon will be) possible to image the structures of proteins doing their thing *au naturel*, in living cells, in real time (see *Science* **258**, 269–271; 1992). But lest we forget the joy of sheer power, the most powerful laser in the world is a petawatt laser hardly larger than a benchtop. (A petawatt is equivalent to a billion megawatts.) On an even smaller scale, it is possible to cram 20,000 highly efficient diode lasers into a space the size of a biggish postage stamp to yield 4,000 watts of laser power that can be used to pump larger lasers.

Much of this work would not have been possible but for a small part of LLNL's operation, the Laboratory-Directed Research and Development Program (LDRD). This exists to review, select and sponsor relatively small, speculative projects dreamed up by LLNL's research staff.

In the old days, the relatively few research programmes were funded *en bloc*, a policy that left plenty of flexibility for the discretionary funding of smaller, spin-off projects. This tendency grew until in 1970 such funding accounted for 15 per cent of the laboratory's budget. But with the passing of time, the same funds had to support an increasing diversity of major programmes, leaving less room for curiosity-driven research. It would probably have become extinct but for a deliberate policy decision in 1985 to allocate 2 per cent of the annual budget to what is now the LDRD. The proportion is now 6 per cent; the upshot is that the LDRD has $59 million to fund its roster of about 140 projects to the tune of between $50,000 and $3 million each. In a way, it is depressing that the funding of serendipity needs a separate, conscious effort. □

SETI

First contact

THOUGHTS of life in other worlds have motivated Frank Drake since boyhood. As a young radioastronomer, he felt that radio might prove the medium of first contact. One night, all alone with a radiotelescope, he detected what seemed to be a purposeful signal from the Pleiades. He reminisces that "it creates a very strong and unusual emotion to think that you may be in contact with another civilization". That signal was a false alarm, "but nevertheless, the seeds had been planted".

Since its beginnings in the 1950s, improved technology has made SETI (the Search for Extraterrestrial Intelligence) more respectable, and Harvard, UC Berkeley, Ohio State University and NASA (Ames and JPL) now have SETI programmes.

Drake is on the NASA Ames team, and is also president of the SETI Institute, a nonprofit corporation that works as a contractor to NASA to undertake the actual work. The SETI project itself is a $100-million programme over ten years (now in its third year) to develop high-performance computer chips that function as multichannel radio receivers. The system now working can monitor 15 million channels simultaneously.

No amount of technology can second-guess extraterrestrial intentions and tell astronomers where they should point their telescopes. The right strategy, therefore, is to look at the nearer stars, because the signals may be the loudest. On the other hand, some may broadcast powerful signals from further away, in which case the nearer stars are no help. As a compromise, the NASA SETI project (or the High Resolution Microwave Survey, as it is to become known) based at Ames is scanning the 1,000 nearest stars, and the complementary search, based at JPL, is looking at the whole sky to pick out the loudest sources.

The first two months of listening have picked up 15 false alarms. Should SETI strike lucky, other telescopes would be brought in to verify any signal, and public announcement would be immediate. What would be its effect on the public? "I think it will cause great excitement, great elation in the world, and will lead — in time — to a great explosion in knowledge and understanding of our civilization, and a very rapidly changing attitude towards ourselves and our future", says Drake, who dismisses the fears of some that contact would have adverse consequences. Interstellar distances are a barrier to exploitation of the Earth from elsewhere, and "if we don't like what we're hearing, we just pull the plug. The fear that these other cultures will turn us into slaves is just science fiction." □