Simply by feeding into the reaction mixture suitably labelled deoxynucleotides the DNA can be labelled to a very high specific activity; it can then be used as a specific probe either for globin genes or for globin messengers and a host of intriguing questions, which cell and molecular biologists would dearly like to be able to answer, are at a stroke rendered experimentally feasible. It should, for example, be possible to find out how many copies of the globin genes are present in a cell, to find out at precisely what stage in erythropoiesis they are first transcribed and to identify nuclear precursors to cytoplasmic globin messengers and follow their maturation. Moreover, there is every reason to anticipate that other species of mammalian messengers, as they become available, will prove to act as templates for reverse transcriptase and therefore as a substrate for the manufacture of genes, a prospect which in the long run is not without its implications for genetic engineering.—From our Cell Biology Correspondent.

NUCLEAR ENERGY

Salting Away Waste

from our Materials Science Correspondent
 "OUT of this nettle, danger, we pluck this flower, safety." Hotspur's concern was war, but his adage is apt for the nuclear power industry. Because radioactivity poses an unmistakable and ever-present threat to people who work in the industry, safety is taken with extreme seriousness and its safety record is one for other, more fatalistic industries to envy. Nonetheless, "environmentalists" often have their knives into the industry: sometimes they worry about the risk of radioactive release into the air, sometimes about "thermal pollution" but most commonly about the supposed dire consequences of the steady accumulation of highly radioactive wastes.

Undoubtedly there are serious problems here: radioactive constituents are separated by remote-controlled chemical processing from spent nuclear fuel, and the concentrate is then usually melted with appropriate additions to form blocks of chemically very stable glass. This glassy concentrate is so extremely radioactive that, in bulk, it heats itself to a temperature of several hundred degrees C. The glass, sealed in metal containers, is buried in man-made vaults; for the future, as quantities increase, the US Atomic Energy Commission hopes to use disused deep salt mines, because salt deposits are apt to be seismically very stable formations and, as further insurance, being plastically deformable, such formations could resist disturbance by earthquakes. The wastes have to stay put for thousands

of years: the question is, can they be trusted to stay put?

Much theoretical and experimental work has been carried out recently in the United States to assess the safety of salt mines. One curious potential problem arises from the presence in natural salt deposits of small droplets of trapped brine. Because the buried radioactive wastes are literally hot, there will be a temperature gradient in the surrounding salt, and it is known that brine droplets will migrate up a temperature gradient (T. R. Anthony and H. E. Cline, *J. Appl. Phys.*, **42**, 3380; 1971). This could be serious, because the brine droplets could progressively spill out of the cavern wall, increase the humidity in the cavern and hasten corrosion of the sealed containers, and then even the stable glass could gradually be attacked and dispersed into other parts of the mine.

Anthony and Cline, who work at the General Electric R and D Centre in Schenectady, have now pursued this intriguing problem a stage further (*Acta Metallurgica*, **20**, 247; 1972). They predict that when a brine droplet reaches the salt surface, some water evaporates, the brine becomes supersaturated, salt is precipitated and seals off a bubble which now contains both brine and some air or water vapour; and furthermore, that such mixed bubbles will turn round and migrate down the temperature gradient. This they confirmed by direct experiments on a KCl crystal. Typically, a small bubble in a gradient of 3 degrees per centimetre at 40° C migrated a few μm per hour.

Anthony and Cline go thoroughly into the physics of the process and then go on to consider the relevant magnitudes as applied to "nuclear crypts". It seems that in the most unfavourable case, liquid/vapour bubbles could move several metres into the salt in a year, carrying with them any stray radioactive material that might conceivably attach to the cavern wall (possibly because of corrosion by the released water). Beyond the distance of a few metres the temperature gradient caused by the self heating must rapidly attenuate, and Anthony and Cline calculate that, because of trapping at grain boundaries in the salt, there is no risk of bubbles continuing to migrate in the much weaker temperature gradient of the Earth itself, or in its gravitational field. The limited dispersal predicted, however, would complicate later exhumation of the wastes in the unlikely event of this being thought necessary. Problems thus exist even for the strategy of burial in deep salt mines, but they seem to be serious only if the need to exhume totally is regarded as a realistic possibility. What this valuable article illustrates is how much scientific care is devoted to every facet of safety

by those responsible for it as distinct from the cavalier irresponsibility of which they are apt to be accused.

The migration of bubbles in salt is just one example of a whole family of processes of especial relevance to nuclear energy, which includes the migration of bubbles of fission-gas in steep temperature gradients present in ceramic nuclear fuels, the dragging of spherical pores by grain boundaries as they move, and the motion of a dislocation loop in an elastic strain field.

GRAVIPERCEPTION

A Cellular Hypothesis?

from our Plant Physiology Correspondent
 RECENT electron microscopic investigations culminating in the elegant work of Sievers and Dolkman, published in the current issue of *Planta* (**102**, 160; 1972), look set to resolve and place on a rational footing one of the oldest controversies in plant physiology. The mechanism by which plant roots perceive the force of gravity, and translate the stimulus into the directional growth response known as geotropism, has exercised the minds of botanists for more than a century. As long ago as 1886, Berthold suggested that gravity was perceived by the movement through the root cells of special starch containing plastids known by analogy with the labyrinthine receptors of animals as statoliths. This theory was amply supported by the classical observations of Haberlandt and Nemeć who, seventy years ago, demonstrated an almost perfect correlation between the occurrence of movable statoliths and the existence of a geotropic response. The 1920s, however, saw the rise of the all-conquering auxin and the development of the Cholodny-Went hypothesis in which it was postulated that unilateral exposure to a gravitational stimulus led to a redistribution of auxin towards the lower side of the organ. Because root growth was inhibited by high levels of auxin such a redistribution would cause the observed downward geotropic curvature.

Although the Cholodny-Went hypothesis was restricted to auxin movements and did not attempt to explain the perception of gravity, nevertheless the statolith theory became virtually discarded. Later, the picture became more complicated by the work of Brauner and his colleagues, who observed a change in electrical potential across the root upon turning it horizontal. Brauner claimed that this so-called geo-electric effect was part of the perception mechanism and caused the redistribution of auxin by an electrophoretic migration. There is, however, no known physical phenomenon which could account for the geo-electric effect,