rally alerting chemicals are mutagenic — 84% of the carcinogens and 66% of the non-carcinogens. All of the 33 aromatic amino/nitro type, two-species carcinogens are mutagenic. For structurally alerting chemicals the *Salmonella* assay showed high sensitivity (88%) but low specificity (33%). Of the 147 non-alerting chemicals — of which 57 are animal carcinogens — only 6 (fewer than 5%) were mutagenic.

Ashby and Tennant conclude that it is pointless to discuss the sensitivity and specificity of the *Salmonella* assay without defining the broad group to which a chemical belongs. The chemical class will determine the result rather then the assay itself. If, for example, an environment were to be screened for potential carcinogens, the *Salmonella* assay will detect the vast majority of the aromatic amino/nitro groups, but will not identify chlorinated aromatics.

The way that the information is set out will provide other researchers with a database that can be interrogated intelligently. Thus, the position of a chlorine atom may be crucial. Neither 1,2-dichlorobenzene nor 1,4-dichlorobenzene are mutagens, yet 1,4-dichlorobenzene causes kidney tumours in the rat and liver cancer in the mouse. Additional chlorine atoms also affect the outcome of carcinogenicity testing. For instance 2,4-dichlorophenol and 2,4,6-trichlorophenol have no structurally alerting features and are not mutagens, yet the second of them causes haematopoietic cancers in the rat and liver tumours in the mouse.

In the final analysis it is the underlying mechanism of carcinogenesis in animals that is important, and whether it is relevant to humans. Aromatic nitro/amino groups on chemicals are structurally alerting features and many chemicals with these features are mutagens in *Salmonella*. Yet, in terms of their carcinogenicity, this 'family' is as disparate as all the others, ranging from potent, two-species, multisite carcinogens such as the dye CI Basic Red 9, to the non-carcinogen 4-nitro-*o*-phenylenediamine, a chemical with three alerting structures attached to a benzene ring. Nevertheless, the fact that DNA damage is probably the stimulus for carcinogenicity with such compounds indicates that a possible hazard to human health exists. But the principle may not apply to the non-genotoxic carcinogens, hence the importance of Ashby and Tennant's claim that the genotoxic–non-genotoxic divide is an appropriate classification for carcinogens.

In support, the authors point out that some markers are uniquely associated with genotoxicity, for example tumours of the lung and Zymbal's gland in rodents. Four other tissues seem to be involved in non-genotoxic carcinogenesis and the underlying mechanisms are worthy of exploration, they claim. Chemicals that cause renal tumours in the rat kidney (such as 1,4-dichlorobenzene) by increasing kidney tubular concentrations of the protein α_2 microglobulin and disrupting calcium reabsorption[13], or increase peroxisome proliferation in rodent liver, or which cause leukaemia or thyroid tumours in rodents, may do so by disturbing the normal genetic control in these sensitive tissues, rather than by the chemical specifically damaging DNA. Thus, say Ashby and Tennant[2], non-genotoxic carcinogenicity is more subtle than the "simple concept of tissue toxicity" put foward by Ames — chemical features can be used to identify potentially genotoxic carcinogens, but homeostatic disturbances induced by other chemicals in individual tissues, rather than direct damage to DNA, determines non-genotoxic carcinogenicity. So use of specific *in vitro* and *in vivo* mutagenicity tests will only identify genotoxic carcinogens.

Three years ago the same authors performed a similar exercise on 222 chemicals[7]. They have now gone further and identified crucial areas of research which will improve our knowledge of mechanisms of rodent carcinogenicity, and the relationship between carcinogenicity in animals and that in humans. □

Alastair Hay is in the Department of Chemical Pathology and Immunology, University of Leeds, Leeds LS2 9JT, UK.

1. Tennant, R. W. & Ashby, J. *Mut. Res.* **257**, 209-227 (1991).
2. Ashby J. & Tennant, R. W. *Mut. Res.* **257**, 229-306 (1991).
3. Ames, B. N. & Gold, L. S. *Science* **249**, 970-971 (1990).
4. Ames, B. N. & Gold, L S. *Proc. natn. Acad. Sci. U.S.A.* **87**, 7772-7776 (1990).
5. Ames, B. N., Profet, M. & Gold, L. S. *Proc. natn. Acad. Sci. U.S.A.* **87**, 7777-7781 (1990).
6. Ames, B. N., Profet, M. & Gold, L. S. *Proc. natn. Acad. Sci. U.S.A.* **87**, 7782-7786 (1990).
7. Ashby, J. & Tennant, R. W. *Mut. Res.* **204**, 17-115 (1988).
8. Miller, J. A. & Miller, E. D. in *Origins of Human Cancer* (eds Hiatt, H. H. *et al.*) 605 (Cold Spring Harbor Laboratory, New York, 1977).
9. Zeigler, E. *Cancer Res.* **47**, 1287-1296 (1987).
10. Tennant, R. W. *et al. Science* **236**, 933-944 (1987).
11. Hoel, D. G. *et al. Carcinogenesis* **9**, 2045-2052 (1988).
12. Shelby, M. D. *Mut. Res.* **204**, 3-15 (1988).
13. Charbonneau, M. & Swenberg, J.A. *Chem. Ind. Inst. Toxicol. Act.* **8**, 1-6 (1988).

A way-out 'asteroid'

On 18 February, Rob McNaught of the University of Adelaide discovered a fast-moving asteroid in the south-polar skies. Earth-approaching asteroids are frequently found these days, but later observations soon revealed that McNaught's object (provisionally designated 1991 DA by the International Astronomical Union) has an orbit around the Sun that is exceptional for an asteroid.

Although 1991 DA was observed while between the orbits of Earth and Mars, its trajectory shows that every 41 years the 5-km diameter object goes out beyond the orbit of the plant Uranus. No other asteroid ventures so far from the Sun. The much larger, enigmatic object Chiron, which was originally designated an asteroid, has in recent years been found to show cometary emissions; even it stays at least 3 astronomical units closer to the Sun (1 AU is the distance between the Sun and the Earth) than 1991 DA.

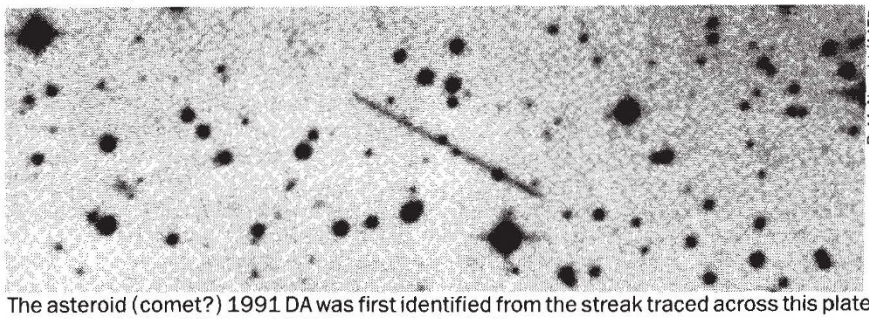
The orbit of 1991 DA is also strongly tilted (62°) to the plane of planetary orbits in the Solar System: it looks like the orbit of a comet. Several astronomers have observed 1991 DA closely, but there is no hint of a coma, the glowing gaseous head that is always evident around comets so close to the hot Sun.

Comets that become trapped inside Jupiter's orbit usually lose their volatile ices and 'die' by the time they have made several hundred passages through the inner Solar System. Evidently, longer-period comets normally get dislodged from orbits like that of 1991 DA long before they can become devolatilized. When they venture close to Jupiter's strong gravity field, they either become trapped in shorter orbits (later to die) or else are ejected far beyond Jupiter.

Conceivably 1991 DA is an asteroid that has somehow recently been dislodged from the asteroid belt. It is much more likely that it is really a comet that has been lucky enough (perhaps because of its high orbital tilt) to avoid close encounters with massive Jupiter, Saturn or Uranus. Survival for tens or hundreds of thousands of years might be long enough for it to lose its volatiles during its brief visits to the inner Solar System. If so, this 'asteroid' is actually a rare burned-out comet.

Clark R. Chapman

Clark R. Chapman is in the Planetary Science Institute, Tucson, Arizona 85719, USA.



R. McNaught/AATB

The asteroid (comet?) 1991 DA was first identified from the streak traced across this plate recorded with the UK Schmidt Telescope in Australia.