to the north by 285±74 km. Later, however, Watkins (*Geophys. J.*, **28**, 193; 1972) pointed out that, although the northern hemisphere palaeomagnetic results for the Brunhes alone are consistent with a dipole offset to the north by 300–400 km, the southern hemisphere data require no such offset. He therefore suggested that the simplest model consistent with data from both hemispheres would have a main centred dipole with a weaker axial dipole some distance to the north.

In a more thorough analysis, Watkins and Richardson now show that the Brunhes palaeomagnetic data are best satisfied by a major dipole offset to the north together with two minor axial dipoles offset arbitrarily to the core-mantle interface (one in each hemisphere). These minor dipoles have moments of 1–4% of that of the main dipole, the one in the southern hemisphere having the same polarity as the main dipole and the one in the northern hemisphere opposing the main dipole. This is apparently the simplest model consistent with all current Brunhes palaeomagnetic results although more complex models could be devised (and may be necessary later to explain better data).

Finally, Bhattacharyya and Leu (*J. Geophys. Res.*, **80**, 4461; 1975) have used the magnetism of rocks indirectly to investigate a much more local effect. From an analysis of magnetic anomalies over Yellowstone National Park, they show that the Curie point isotherm below this geothermal area is particularly shallow. This is only to be expected and in any case has been proved before using other methods. The point of this confirmation, however, is its suggestion that aeromagnetic data may prove useful in regional reconnaissance for potential geothermal energy resources. □

Tail-wagging antibodies?

from C. C. F. Blake

Now that X-ray studies have established a broad understanding of the antigen binding function of immunoglobulins, attention is being turned to the Fc region and how its complement fixation and B-cell activation functions are influenced by binding of antigen.

The first successful structural study of a whole myeloma protein, the IgG1 Dob, by both low resolution X-ray analysis and electron microscopy (Sarma *et al.*, *J. biol. Chem.*, **246**, 3753; 1971; Lebaw and Davies, *J. ultrastr. Res.*, **40**, 349; 1972) revealed that the molecule was T-shaped, but little else. Recently Huber and his colleagues (Colman *et al.*, *J. molec. Biol.*, **100**, 257; 1976) reported a second low resolution study, of the IgG1 Kol, which has produced much more information. There are two reasons for this: first, high-resolution structural information on the Fab region is now available and second, the Kol protein does not have the deletion in the Fab–Fc hinge region that the Dob protein has. Since the resolution of Huber's map is only 5 Å, only the quaternary structure of the molecule—the arrangement of the various domains—can be analysed in any detail. Changes at this level of structure, however, could be highly significant, and some very intriguing results have been obtained, even though, or rather because, there is no electron density for the Fc region of the molecule.

One of the characteristics of X-ray analysis of crystal structures is that it is only possible to see side-chains or parts of molecules that are positionally stable in the crystal. Thus the lack of electron density in that part of the crystal that should contain the Fc of Kol, must indicate that the whole region can, and does, take up at least two orientations relative to the well-defined Fab regions. Huber has interpreted this as indicating the presence of a hinge in the molecule at the point at which the electron density fades out—immediately C-terminal of the inter-heavy chain disulphide bridges. If this is so the hinge is different from the classical one proposed to account for the Y→T transformation which must be N-terminal of these bridges. It should be noted that the angle between the two Fab arms is 125° in Kol, in contrast to the 180° found in Dob.

Yet a third hinge region may be present in the molecule, coincident with the switch regions between the V and C domains of the Fab arms. Interpretation of the Fab region of the Kol protein in terms of the known structures of the human V_k dimer fragment Rei, and the mouse McPC 603 Fab fragment, has shown that the V and C domains are not in the same relative orientation as that found in the Fab fragments so far analysed. The difference can be judged by the angle of intersection of the pseudo-dyads that relate the light and heavy chains in the two domains, which changes from 120° in the Fab fragments to 170° in the Kol protein. Colman *et al.* refer to this change as "bending the elbow" of the Fab arms—in the Kol protein therefore the arms are almost straight.

Huber and his colleagues speculate that these two new hinge regions may permit antibodies to act as allosteric proteins, in which the allosteric effect is transmitted through the polypeptide chain from one domain to another. They suggest the possibility that hapten binding is accompanied by a "bending of the elbow" and that the elbow movement is sensed by the hinge causing a change in the Fc region that by implication influences complement fixation. Although there is little other evidence that complement fixation is accompanied by conformational changes, the present hypothesis is certainly plausible in view of the extraordinary domain structure of the immunoglobulins, and we now await the results of hapten binding to the Kol protein with considerable interest. □

Tunguska revisited

from David W. Hughes

At about 7.17 a.m. local time on June 30, 1908 in the basin of the River Podkamennaya Tunguska, Central Siberia (latitude 60° 55′N, longitude 101° 57′E) a gigantic explosion occurred. The ancient trees of the mighty Yenissi taiga were torn up by their roots and in places piled up in thick layers by the explosion wave, their trunks pointing radially away from the centre of the explosion. The devastation extended over an area of radius 30–40 km, the centre of the area having been ravaged by fire, searing being traceable for 18 km. A farmer 60 km away told how his shirt was almost burnt off his back, the explosion throwing him off the steps of his house and several feet across the ground. Eye witnesses up to 500 km away saw, in a cloudless sky, the flight and explosion of a blindingly bright, pale blue bolide, "which made even the light of the Sun appear dark". This left in its wake a thick dust trail. The explosion took the form of a vertical column of fire and threw incandescent matter up to a height of 20 km. The sound of the explosion, like gun fire, reverberated thousands of kilometres away, seismographs registered an earthquake; the explosion air wave, recorded on microbaragraphs in many meteorological stations, went twice round the world. Magnetic disturbances similar to those subsequently recorded after atmospheric nuclear explosions were recorded at the Irkutsk Observatory.

After the explosion the nights were expectionally bright over Western Asia and Europe, the enhanced night brightness slowly diminishing and disappearing after two months. In mid-July, two weeks after the explosion, the coefficient of transparency of the atmosphere was found to be noticeably depressed over California. This, it was suggested. was due to the loss of vast amounts of material from the incident body as it travelled through the atmosphere. Observations indicated this loss to be several million tons, a hundred times more than the normal annual influx of meteoric matter.

Fortunately the fall region was very sparsely populated, the only inhabitants being scattered bands of nomadic Evenki reindeer herders. Due to the untimely occurrence of political upheavals in Russia the first cursory inspection of the impact site did not take place for 19 years when eventually Leonid A. Kulik headed an expedition organised by the Academy of Sciences of the USSR.

Many expeditions have since visited the area and many papers have been written discussing the phenomenon and putting forward ideas as to its cause. One of the latest papers appeared in a recent issue of *Physics of the Earth and Planetary Interiors* (**11**, 61; 1975). In it Ari Ben-Menahem of the Adolpho Bloch Geophysical Observatory, Rehovot, Israel re-analyses the old seismograms of the Tunguska event and deduces the parameters of the original explosion by comparing the old data with contemporary records of the seismic and acoustic effects of the air explosion that took place at Lop-Nor, Sinkiang on October 14, 1970 and the series of air explosions from nuclear tests at the USSR test site at Novaya Zemlya (74°N, 150°E).

The Tunguska sound waves were of acoustic modes S_0 and S_1 and travelled at group velocities between 280 and 310 m s^{-1}. The seismic event was excited by the air explosion at the source, energy being radiated outward from the epicentre by a series of wave motions. The Rayleigh mode, a rolling motion of the Earth's surface, moved at about 2.7 to 3.5 km s^{-1}. SH body waves, where the displacements are horizontal and perpendicular to the direction of propagation were recorded only at Irkutsk and the time of their arrival, coupled with arrival times of other waves at other observatories gives, according to Ben-Menahem, the explosion time to be 00 h 14 m 28 s UT. This time differs by about 30 s from previous estimates. The time delay between the arrival of the SH wave and the Rayleigh wave indicates that the main explosion occurred at a height of 8.5 km above the ground. The direction and extent of fallen trees around the epicentre suggest that this phenomenon was caused by the superposition of two waves—a spherical shock wave (due to the explosion, equivalent to a vertical point impulse of 7×10^{18} dyne s) and a conical ballistic wave (due to the moving incident object, equivalent to a horizontal point impulse of 1.4×10^{18} dyne s). The extent of the damage and the magnitude of the acoustic and seismic waves indicate that the explosion had an energy of $(5\pm1)\times10^{23}$ ergs, equivalent to 12.5 ± 2.5 megatons of TNT.

Ben-Menahem does not leap into the controversy as to the actual form of the incident object simply referring to it as a "UFO". Jackson and Ryan (*Nature*, **245**, 88; 1973) thought it might have been a black hole with the mass of a large asteroid (10^{20}–10^{22} g) and a negligible geometrical radius. This would have shot straight through the Earth but unfortunately for the theory (although fortunately for us) the exit point, latitude, 40–50°N longitude 30–40°W, in the mid-Atlantic was not marked by an equally severe shock and blast wave. Hunt, Palmer and Penny (*Phil. Trans. R. Soc. Lond.*, **A252**, 275; 1960) consider the possibility of an extraterrestrial almost-critical mass of fissionable material becoming tamped on entering the atmosphere. It is difficult, however, to conceive how a sufficient amount of, say, deuterium and tritium can be compressed and heated to several million degrees centrigrade and maintained in that state sufficiently long for the self heating to carry the reaction to the explosive stage merely by entry into the Earth's atmosphere. Cowan, Athuri and Libby (*Nature*, **206**, 861; 1965) suggest that an incident anti-matter body annihilated itself in the atmosphere, but no large anti-matter bodies have, as yet, been observed and it is hard to understand how it penetrated to such a depth in the atmosphere and why the explosion maximised at the end of the trajectory and not midway along it.

The most likely theory, that a small comet struck the Earth, was put forward by Whipple (*Q. Jl R. Meteorol. Soc.*, **56**, 287; 1930) and Astapovich (*Astr. J.*, **10**, 465; 1933). The trajectory of the bolide indicated that the comet was travelling in the opposite direction to the Earth and that the head-on collision was at a velocity of 60 km s^{-1}. The cometary nucleus, which, according to Whipple, is a large dirty snowball—a loose collection of dust and rock interspersed with water, methane and ammonia ices—exploded above the Earth's surface. If most of the energy came from the dissipation of kinetic energy and only a negligible portion from the chemically explosive reactions between the air and the radicals in the nucleus then the mass of the incident comet can be calculated to be approximately 3×10^{10} g. The fact that this comet nucleus has a diameter of about 40 m, more than an order of magnitude below the diameters estimated for visual comets, explains why it wasn't seen as it approached on its collision course to the Earth.

Further evidence favouring this hypothesis is that the night sky luminescence after the fall was only observed over Siberia, Russia and Western Europe. Calculations of the comet orbit indicate that the dust and gas tail, which is directed away from the Sun, extended in a north-westerly direction from the point of impact. The dissipation of this tail in the atmosphere increased the night sky brightness by about 50–100 times. The discovery of many small (5–450 μm diameter) magnetite and silicate globules in soil samples taken from the Tunguska site also supports the comet hypothesis. These were formed when molten 'rain drops' of dust solidified as they slowly drifted to Earth after the explosion of the retarded nucleus. Flux estimates indicate that a cometary nucleus of this size will hit the Earth about every 2,000 yr, the rarity of the event giving ample justification for visiting Tunguska yet again.

Far-infrared balloon astronomy

from a Correspondent

THE far-infrared region of the electromagnetic spectrum—wavelengths between 20 μm and 1 mm—is probably the last regime to be explored by the astronomer. The reason for this apparent lack of resolve is not that the wavelength range is uninteresting—far from it when we realise that the majority of the many clouds of dust scattered throughout our Galaxy radiate most of their energy at precisely these wavelengths. The problems are technological; in the far-infrared, the Earth's atmosphere is virtually opaque to external radiation because of severe attenuation by water vapour molecules. There are very poor transmission windows at wavelengths of 350 μm, 450 μm, and around 800 μm, but these are accessible only from very high, dry sites such as Mauna Kea at 14,000 feet in Hawaii. Even then, transmission figures better than 30% are very rare. The obvious answer is to observe from above the absorbing layers in the atmosphere, and with dramatic improvements in balloon astronomy, many exciting discoveries are being made.

The University College London (UCL) group, led by R. E. Jennings, has pioneered balloon far-infrared astronomy and its latest flights have produced a catalogue of far-infrared sources in the Galactic plane. The 40-cm telescope, operating at an altitude of about 100,000 feet is directed to raster scan selected regions of the Milky Way, most of these having