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The twentieth century had more than its fair share of exciting discoveries in science including the molecular basis for life and the quantum behaviour of microscopic particles. But, arguably, the most exciting discovery of twentieth century is that of the expansion of the universe. We know now that distant galaxies in the universe are moving away from each other with speeds which increase with distance. One person who deserves lion's share of credit for this discovery is astronomer Edwin Hubble whose work defined our (somewhat insignificant) place in the cosmos.

Hubble was born in Missouri on November 20 1889. He obtained his bachelor's degree from University of Chicago and went to Oxford as a Rhodes scholar. Later on — after serving for a short time in the army — he joined the Mount Wilson observa-

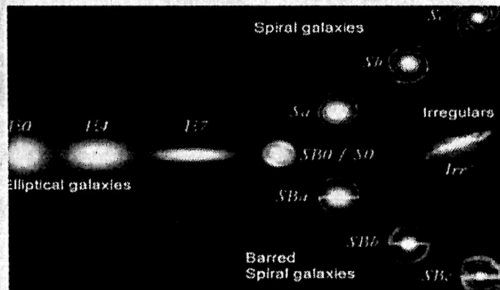
tory in California in 1919. At that time, Mount Wilson had the world's largest optical telescope, the 100 inch Hooker telescope, which Hubble used to make many of his remarkable discoveries in the period between the two world wars.

The key one amongst them was the discovery that distant galaxies are receding from us with a speed that is proportional to their distance from us. When a moving galaxy emits light which is observed from Earth, the light will undergo a shift in the wavelength. The shift will be towards the redder side of the spectrum if the galaxy is receding from us. (This effect is very similar to the change in the pitch we observe in the whistle of a train when it

Making the Universe move



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From left: Various types of galaxies sorted into a 'Tuning Fork' diagram; Edwin Hubble at the eyepiece of the Palomar telescope.

moves away from us compared to when it is stationary.) By measuring the shift in the spectral lines of the light from the galaxy, one can infer their speed. If the distance to the galaxy is known from some other independent measurement, then one can correlate the speed with the distance to the galaxy.

This is roughly what Hubble did

in a discovery paper in 1929 which was followed by a series of papers co-authored with Humason (who also deserves credit for discovering the expansion of the universe) during the period 1931-36. These later papers verified and extended the Hubble relation to sufficiently large redshifts thereby laying the foundation for modern cosmology.

The significance of this result



cannot be overstated. Einstein had a chance to predict the expansion of the universe before it was discovered based purely on theoretical grounds. But he missed it because he thought the notion of an expanding universe was too drastic and actually tinkered with his equations to obtain a static universe.

During the 1920s, Hubble also made several other contributions to cosmology. He proposed a classification scheme for galaxies usually called the tuning-fork diagram which is still used in spite of the fact that it has outlived its original interpretation. The two arms of the tuning fork represented two types of galaxies, spiral and elliptical. In fact Hubble's work opened out the vast world of galaxies well beyond the extent of the Milky Way.

Next week: The galactic neighbours

Astrophysicist Jayant Narlikar and theoretical physicist Thanu Padmanabhan will contribute to DNA's special series through 2009, designated the International Year of Astronomy.