– recently identified at X-ray wavelengths, and possibly in the visible region as well – are the only positively identified sources. However there are a very large number of transient bursts of gamma rays which are also observed, and these cannot yet be satisfactorily explained. These **gamma-ray bursters** appear to produce essentially instantaneous events, ranging in duration from only tenths of a second to about a minute. Their detection by various spacecraft in different parts of the Solar System has enabled the directions of the sources to be determined, but no certain identification with any object has ever been made, although their distribution suggests that they are likely to be galactic objects. One very energetic burst (and later, lesser ones) appeared to correspond with the radio source N49, thought to be a supernova remnant in the Large Magellanic Cloud. Oscillations with a period of eight seconds in the case of this burst, and four seconds in another event elsewhere, point to neutron stars as probable sources, as they could rotate at such rates. The mechanism for the production of these intense bursts of gamma rays is quite unknown; however, it has been suggested that collisions between asteroids and neutron stars might be involved, which could account for the apparent single event per source. A more 'normal' accretion mechanism in a binary system has also been proposed, but this might be expected to show frequent bursts. For the time being these objects remain a problem, although one possible candidate for an optical burst has been found.

Black holes

A neutron star, like a white dwarf, can have only a certain maximum mass. Above this limit, thought to be about 4 $M_\odot$, it will suffer a rapid and unrestrained collapse into a very much higher density régime – a black hole. Current theory predicts no limit to the collapse, so the density goes to infinity as the radius shrinks to zero. This mind-boggling object of zero radius is known as a **singularity**. It is surrounded by a region, the boundary of which is called the Schwarzschild radius (R_s), named after its discoverer Karl Schwarzschild. This is the outward distance at which the **escape velocity** (the velocity required to escape from the gravitational pull of the collapsed body) equals the velocity of light. Any

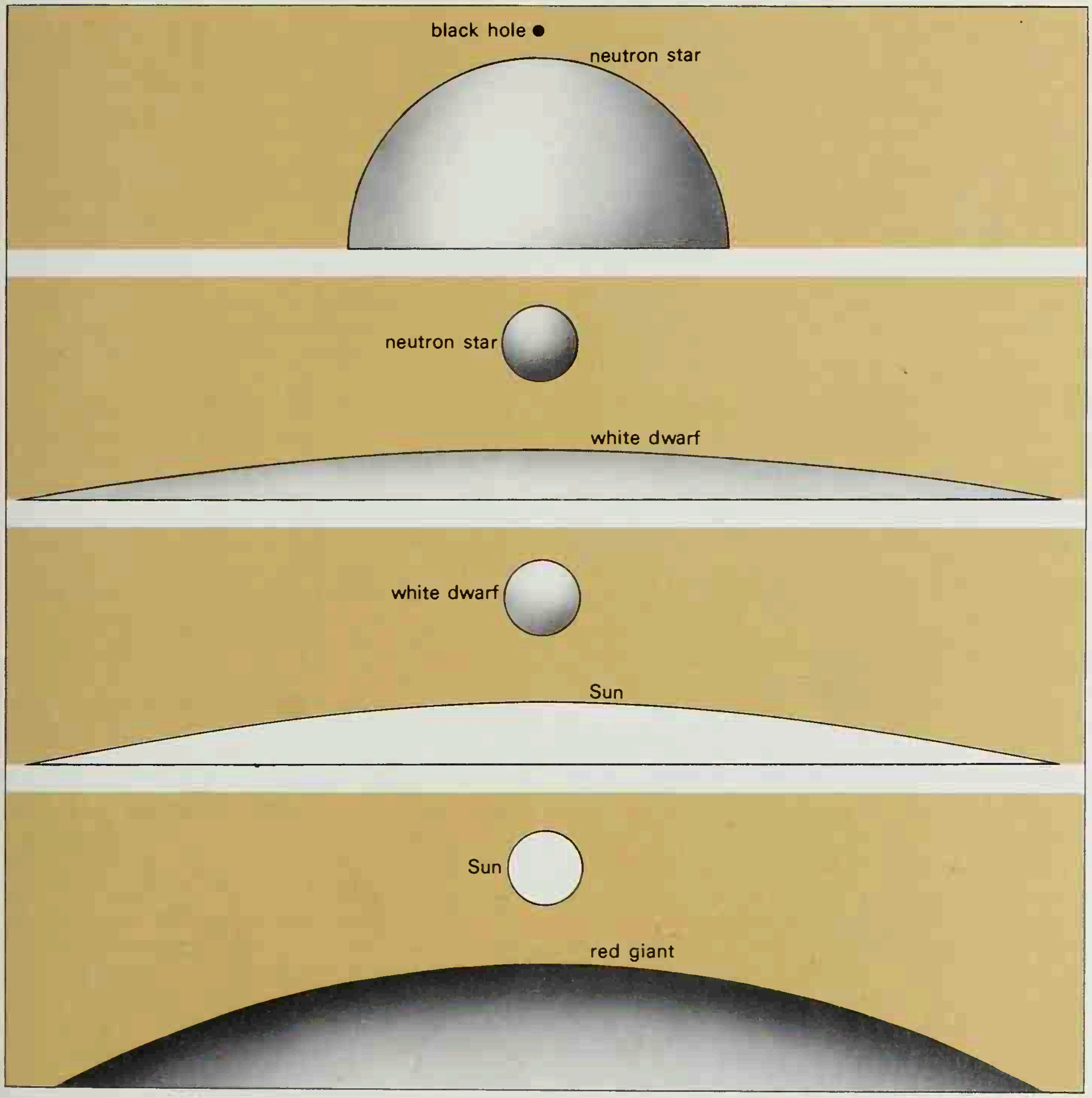

Fig. 3·27
Relative sizes of stellar bodies, all of one solar mass, showing the enormous range of density spanned by stars in different phases of evolution.