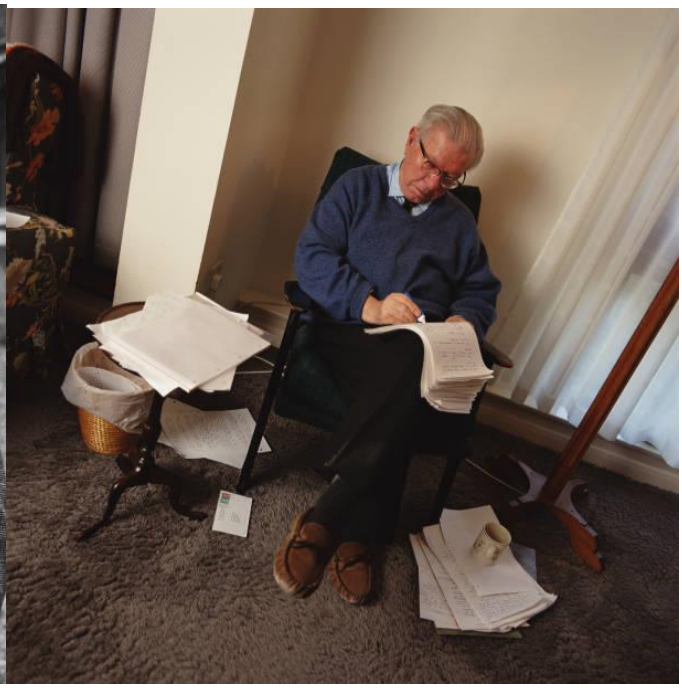
Teacher notes

Fred Hoyle – fighting for lost causes or the thin line between a genius and a crank.

I first learned of Fred Hoyle when I read his science fiction book "The Black Cloud" which was given to me as a present when I was in high school. I loved the book – it gave an interesting and attractive impression of what intelligent extra-terrestrial life might look like.

Fred Hoyle (1915-2001) is famous for two main things: the theory of stellar nucleosynthesis and the Steady State Theory of cosmology (the latter with H. Bondi and T. Gold).

In the 1930's no one had any idea of how the elements were formed. In a groundbreaking paper of 1957, Hoyle along with three other collaborators from Caltech showed how nuclear fusion reactions in stars create elements heavier than hydrogen. And that elements even heavier than iron were created as heavy stars explode as supernovas hurling into space the elements that had been created over millions of years. One of Hoyle's collaborators on that paper, W. Fowler, went on to share the 1983 Nobel Prize in physics (along with S. Chandrasekhar) but not Hoyle (or the other two collaborators) – more on this later.

In 1948, Hoyle, Bondi and Gold came up with an interesting theory of cosmology, a theory that challenged the Big Bang theory. The Big bang theory postulated that the entire Universe, all its mass and energy, as well as space and time themselves, were created out of nothing at a singular point some 14 billion years ago in a phenomenal "explosion". Stars and galaxies started forming afterwards. We observe red shifted light from the distant galaxies which is interpreted within Einstein's theory as a stretching of the space in between galaxies. The Universe is expanding. Interestingly, it was Hoyle

himself who coined the term “Big Bang”, somewhat pejoratively, in a BBC interview. And when he met Lemaitre, a Belgian physicist who had worked out the mathematics of the Big Bang, he is supposed to have said “Here comes the Big Bang man”.

Hoyle’s theory maintained that the Universe is in a steady state. How could this be since the Universe is expanding? Because, according to Hoyle, matter is continuously being created in such a way as to fill the gap in between the galaxies that move away from each other. The estimated production of matter amounted to about one hydrogen atom being created per cubic meter per billion years! This production of matter out of nothing was a major criticism of the Hoyle theory. Hoyle himself saw the irony in this and frequently discussed it: Big Bang theorists were willing to accept that the entire Universe was created out of nothing in an instant but the continuous production of matter in the Steady State theory bothered them. But the final nail in the coffin of the Steady State theory came in 1965 when A. Penzias and R. Wilson discovered Cosmic Microwave Background (CMB) radiation that had no apparent specific source. The CMB is a natural consequence of the Big Bang theory but has no place in the Steady State theory. According to the Big Bang, the Universe started out very hot and very dense. As the Universe expanded, it cooled down. It took about 300 000 years for neutral atoms to form. Just before that time, matter consisted in the form of protons, neutrons, electrons and photons. The photons interacted (scattered off electrons) and could not travel large distances. The Universe was opaque. But after neutral atoms formed, the photons could pass through them unimpeded and could travel large distances. This is the light that Penzias and Wilson detected. In the vast times since the emission of that light, the Universe expanded, space stretched, and along with it all length scales stretched increasing the wavelength of the photons to microwave wavelengths in thermal equilibrium at a temperature of 2.7 K. The existence of the CMB is the strongest piece of evidence in favor of the Big Bang model. The Steady State theory was abandoned even by the very few who took it seriously but not by Hoyle who made numerous unconvincing attempts to explain the CMB in the Steady State theory until the very end.

As mentioned above, Hoyle’s great contribution to Astrophysics was his work on the creation of the elements, nucleosynthesis. But he was denied a Nobel prize. It is suspected that an event in 1974 may have ruined his chances of getting the prize. In 1974 A. Hewish and M. Ryle got the Nobel prize for the discovery of pulsars, rapidly rotating neutron stars. Hoyle had a heated debate with Ryle bemoaning the exclusion of Jocelyn Bell, the graduate student in the Hewish-Ryle group who actually made the discovery (see the Teacher note on Four women in physics). The Nobel committee may not have liked the controversy that was created and so he was never again considered for that honor. Interestingly, it was Hoyle who, after listening to the colloquium lecture by Hewish announcing the discovery of pulsars, explained what was going on. With no prior information and listening for 45 minutes he was able to come up with the theory that the radiation detected by Bell was radio waves emitted by the rapidly rotating neutron star’s magnetic field. Not many physicists can do this sort of thing.

Hoyle was appointed to the Plumian Professorship at Cambridge in 1958 and kept that position until his resignation in 1972. He founded the Institute for Theoretical Astronomy which for many years was the premier institution of its kind. But after leaving Cambridge he became a bit of a loose cannon ball writing and publishing controversial material that left audiences more and more convinced that he was a crank. He thought that evolution was way too complex to have originated by chance; some form of

alien consciousness must have directed it. He believed that interstellar dark matter was composed of bacteria that provided the origin of life everywhere (his theory of Panspermia). He claimed that archeopteryx fossils were a hoax. He theorized that diseases such as influenza and polio were carried by comets. He had his own theory of gravity that went nowhere. And so on.

Fred Hoyle was a brave man who had ideas, challenged the establishment by forcing it to come up with better counterarguments to his positions and left an indelible mark on the Cosmology of the 20th century.