= Dragon 's Egg =

Dragon 's Egg is a hard science fiction novel written by Robert L. Forward and published in 1980 . In the story , Dragon 's Egg is a neutron star with a surface gravity 67 billion times that of Earth , and inhabited by cheela , intelligent creatures the size of a sesame seed who live , think and develop a million times faster than humans . Most of the novel , from May to June 2050 , chronicles the cheela civilization beginning with its discovery of agriculture to advanced technology and its first face @-@ to @-@ face contact with humans , who are observing the hyper @-@ rapid evolution of the cheela civilization from orbit around Dragon 's Egg .

The novel is regarded as a landmark in hard science fiction . As is typical of the genre , Dragon 's Egg attempts to communicate unfamiliar ideas and imaginative scenes while giving adequate attention to the known scientific principles involved .

= = Plot summary = =

= = = The neutron star = = =

Half a million years ago and 50 light @-@ years from Earth , a star in the constellation Draco turns supernova , and the star 's remnant becomes a neutron star . The radiation from the explosion causes mutations in many Earth organisms , including a group of hominina that become the ancestors of Homo sapiens . The star 's short @-@ lived plasma jets are lop @-@ sided because of anomalies in its magnetic field , and set it on a course passing within 250 astronomical units of the Sun . In 2020 CE , human astronomers detect the neutron star , call it " Dragon 's Egg " , and in 2050 they send an expedition to explore it .

The star contains about half of a solar mass of matter , compressed into a diameter of about 20 kilometers (12 miles) , making its surface gravity 67 billion times that of Earth . Its outer crust , compressed to about 7 @,@ 000 kg per cubic centimeter , is mainly iron nuclei with a high concentration of neutrons , overlaid with about 1 millimeter (0 @.@ 039 inches) of white dwarf star material . The atmosphere , mostly iron vapor , is about 5 centimeters (2 @.@ 0 inches) thick . The star shrinks slightly as it cools , causes the crust to crack and produce mountains 5 to 100 millimeters (0 @.@ 20 to 3 @.@ 94 inches) high . Large volcanos , formed by liquid material oozing from deep cracks , can be many centimeters high and hundred meters in diameters , and will eventually collapse , causing starquakes .

Around 3000 BC Dragon 's Egg cools enough to allow a stable equivalent of " chemistry " , in which " compounds " are constructed of nuclei bound by the strong force , rather than of Earth 's atoms bound by the electromagnetic force . As the star 's chemical processes are about one million times faster than Earth 's , self @-@ replicating " molecules " appear shortly and life begins on the star . As the star continues to cool , more complex life evolves , until plant @-@ like organisms appear around 1000 BC . One lineage of these later became the first " animals " , the earliest of these stealing seedpods from sessile organisms and some later lineages becoming predators .

The adults of the star 's most intelligent species , called cheela (no flexion for gender or number) , have about the same mass as an adult human . However , the extreme gravity of Dragon 's Egg compresses the cheela to the volume of a sesame seed , but with a flattened shape about 0 @.@ 5 millimeters (0 @.@ 020 inches) high and about 5 millimeters (0 @.@ 20 inches) in diameter . Their eyes are 0 @.@ 1 millimeters (0 @.@ 0039 inches) wide . Such minute eyes can see clearly only in ultraviolet and , in good light , the longest wavelengths of the X @-@ ray band .

= = = Growth of civilization = = =

In 2032 , a cheela develops the race 's first weapon and tactics while overcoming a dangerous predator . In November 2049 a human expedition to Dragon 's Egg starts building orbital facilities . The rest of the story , including almost the whole history of cheela civilization , spans from 22 May

2050 to 21 June 2050 . By humans ' standards , a " day " on Dragon 's Egg is about 0 @.@ 2 seconds , and a typical cheela 's lifetime is about 40 minutes .

One clan organizes the first cheela agriculture , which brings predictable food supply but provokes grumbling about the repetitive work . Shortly after , a volcano emerges in the area , and the clan invents the first sledge to carry food from more distant sources . However , within a few generations the volcano pollutes the soil . One clan leads its population on a long , arduous journey to new territory that is fertile and uninhabited . Although one genius invents mathematics to calculate and measure the band 's food supply , the situation is desperate and the clan 's survival depends on the self @-@ sacrifice of the oldest members .

Over the course of generations , the cheela come to worship the humans ' spacecraft as a god , and their records of its satellites ' movements cause them to develop writing . Several generations later , the cheela build an arena to accommodate thousands of worshippers . The humans notice this novel and very regular feature , conclude that intelligent beings inhabit the star , and use a laser to send simple messages . Cheela astronomers gradually realize that these are diagrams of the spaceships , its satellites and its crew ? impossibly spindly creatures , who communicate with frustrating slowness , and are apparently almost 10 % as long as the cheela 's great arena . A cheela engineer proposes to send messages to the humans . As her attempts to transmit from the civilization 's territory are ineffective , she travels to a mountain range to transmit directly under the spacecraft ? conquering the fear of heights that is instinctive for flattened creatures living in 67 billion g . The humans recognize her message and realize that the cheela live a million times faster than humans .

Since real time conversations are impossible , the humans send sections of the expedition 's library . After reading an astronomy article , a cheela realizes that the supernova half a million human years ago created both their races . Many cheela generations later , but only a few hours for humans , cheelas develop gravity manipulation . A few generations later , a cheela spacecraft visits the human one . Although they still need extreme gravity fields to survive , the cheela can now control them precisely enough for both races to see each other face @-@ to @-@ face in safety . The cheela have decided that transferring their technologies , now far advanced of humans ' , would stunt humanity 's development . However the cheela leave clues in several challenging locations , before going their separate ways .

= = Development history = =

Writer Robert L. Forward described being inspired by astronomer Frank Drake 's suggestion in 1973 that intelligent life could inhabit neutron stars . Physical models in 1973 implied that Drake 's creatures would be microscopic . By the time Forward was outlining the book , newer models indicated that the cheela would be about the size of sesame seeds . Later Forward found an earlier letter in which he discussed the idea of high @-@ gravity life in the Sun with science fiction novelist Hal Clement .

Forward was the scientist and Larry Niven the author in a tutorial on science fiction writing , and later that evening Forward and Niven agreed to collaborate on a novel on aliens on a neutron star . However , Niven soon found himself too busy with Lucifer 's Hammer , on which he was already co @-@ writing with Jerry Pournelle . Forward wrote the first draft himself , but several publishers suggested the story should be rewritten by Niven or Pournelle ? who were still busy . Finally editor Lester del Rey provided comments that guided Forward through two rewrites , and del Rey then bought the novel . Forward described the work as " a textbook on neutron star physics disguised as a novel " .

= = = Publication history = = =

In English :

In other languages :

= = Literary significance and reception = =

Science fiction critic John Clute wrote that the novel " generates a sense of wonder that is positively joyous " , saying it was " a romance of science " . Chris Aylott described it as " a minor classic of science fiction ? one that shows off both the best and worst elements of hard SF . ... the ideas definitely come first . " He found the writing of the human cast dull , but appreciated Forward 's ability to share his fascination with the cheela and to create communications between races that lived at vastly different speeds .

Lambourne , Shallis and Shortland consider that the research and detailed construction of the scenario make Dragon 's Egg an excellent example of hard science fiction . Scientist Seth Shostak described the book 's science as " fanciful but impossible to dismiss " .

John Pierce also regarded Dragon 's Egg as hard science fiction at its best , while Forward 's later novel Martian Rainbow (1991) was the genre at its worst . Both novels have cardboard human characters , but this does not matter in Dragon 's Egg , where the focus is on the deeper personalities of the cheela characters . The novel even makes readers care about the fate of an unsympathetic cheela ruler , whose rejuvenation treatment fails catastrophically . Pierce wrote that the best works of this genre create a literary experience , but one of an unusual kind . Instead of offering a metaphor for a reality the reader already recognizes , they create new realities in which the reader is caught up .

Robert Lambourne regards Forward , especially in Dragon 's Egg , as the successor of Hal Clement , whose Mission of Gravity exemplifies the most strongly science @-@ based science fiction . In Lambourne 's opinion hard science fiction authors like Clement , Forward and their successors have been relatively few but have strongly influenced both the genre 's evolution and the public 's perception of the genre .

= = Awards and nominations = =

Dragon 's Egg won the 1981 Locus Award for First Novel and placed 14th in Locus ' SF Novel category .

= = Sequel = =

In 1985 Forward published Starquake , a sequel to Dragon 's Egg . Lambourne , Shallis and Shortland consider Starquake ? s scientific background as rigorous as Dragon 's Egg 's . In this novel , a starquake disrupts cheela civilization , while humans aboard the spacecraft Dragon Slayer deal with their own problems .