# *f9* What advantage accrues to a cud-chewer?

< bovid ruminant ungulates, yogurt >

*My cow going on*
*into the creek from this paspalum-*
*thatched tunnel-track*
*divides her hoofs among the*
*water's impediments,*
*clastic and ungulate stones.*

—Les Murray *Learning Human*.[1]

The food that a plant cell holds is packaged interior to the cell's wall that is (mostly) an interwoven network of cellulose and pectin. This cell wall can be mechanically rent by chewing and stomach churning in mammals (in reptiles aided often by gastroliths; in birds by grit in the crop) but it cannot be digested away except by organisms that produce a mixture of synergistically acting enzymes as depolymerizing cellulase produced by termites and the redclaw crayfish (*Cherax quadricarinai tus*), and, as first described by Herman Popeijus in 2000, pectinase produced by some nematodes and, importantly, by some animal symbiotic microbes.[2]

*Note*: Cooking, which humans do, softens vegetables but does not burst the cells open. When you crunch down, say, on a cooked water chestnut, cracks produced pass through the cells. For carrots, however, heating will have destroyed the carbohydrate pectin that glues the cells together. Then cracks skirt around the cells.[3]

The Neogene is characterized by the evolution of a group of artiodactyls that are of special importance to humans: the *bovid* ruminant ungulates. These animals can survive with a poor diet of nothing but grass leaves (and not grain). Proteins in their diet are provided by symbiotic microorganisms (certain bacteria, protists, fungi, and viruses) that live in the anaerobic and alkaline environment of their rumen (forward one of four stomach chambers).[4] These microorganisms in the rumen are able to digest the cellulose (***Figure f9.1***) of plant-cell walls, and the cud is then further processed by regurgitation and chewing (grinding). Lowing of the cow is to vent methane, a product of the process. The swallowed product ultimately passes through the rumen into the acid environment of the remaining stomach chambers for further processing and then on into the intestines.

A clue to the evolution of the bovid ruminants is found in the gene that encodes for a digestive enzyme that enables the cud-chewing animal to digest the food that the foregut bacteria produce. This is identified as a ribonuclease and the gene that encodes it is known from 40 mammal species. In each of these, the gene is not identical, but because the mammal species are known to be related by their fossil record, the varieties can be considered to have arisen from a common ancestor. The evolution of the ribonuclease producing genes can be backtracked by applying the principle of parsimony. Parsimony is a presumption of evolution by the smallest number of mutations. The time scale for the evolution of artiodactyl ribonuclease (***Figure f9.2***) is known from the fossil record. In the laboratory the 'ancestral' genes can be assembled and they can be expressed to see what 'ancient' protein they in fact do encode. These proteins (enzyme in this case) must be viable in the conditions (such as the rumen environment) in which they are deemed to have existed. From such a study, Thomas M. Jermann in 1955 has discovered that the ribonuclease that encodes for the digestive enzyme in artiodactyls arose from a non-digestive ancestor about 40 million years ago when the advanced ruminants (antelopes, deer, goats, and oxen) diverged from ancestral types (represented today by pigs, hippopotamuses and camels). ❑

*Figure f9.1* **Cellulose**, the major component of the cell walls in plants, is the most abundant organic compound on Earth. A polymer of glucose molecules, cellulose would be an immediate source of glucose, were its beta(β)-glucose molecules like alpha(α)-glucose molecules in starch and glycogen, for animal enzymes can hydrolyze the bonds between the alpha-glucose units in starch and glycogen but cannot hydrolyze the beta-glucose bonds in cellulose. Indigestible cellulose remains as roughage in the digestive tract and is eliminated in the feces of animals. However, in the alkaline and anaerobic environment of the vatlike forward stomach chamber of four (rumen, reticulum, omasum, and abomasum) in ruminants (such as cattle, sheep, and deer), microorganisms (certain bacteria, protists, fungi, and viruses) are capable of producing cellulose-digesting enzymes and their fed mass is in turn animal-digestible food (as is yogurt).[5]

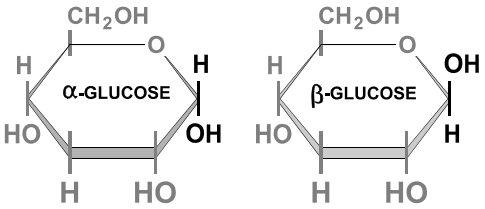


*Figure f9.2* [6] Parsimony analysis graph of reconstructed ancient artiodactyl ribonuclease beginning with bovine ribonuclease A. This graph, chosen out of 14 alternatives in a study by Thomas M. Jermann, accords to what is known of the fossil record and the biological classification of living artiodactyls. The time scale is approximate. Lines of descent traced back from the present join at when a common ancestral ribonuclease (identified by the letters a through j) existed for that group.