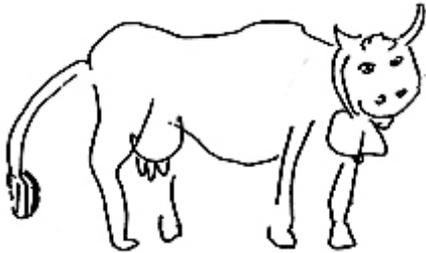


NARAYANA'S COWS

TOM JOHNSON

The text is neither musical analysis, nor a math lesson, nor comic relief. It should be delivered simply and directly as an integral part of the piece, either by the musicians or by someone else.



NARRATOR:

Narayana was an Indian mathematician in the 14th century, who proposed the following problem: A cow produces one calf every year. Beginning in its fourth year, each calf produces one calf at the beginning of each year. How many cows are there altogether after, for example, 17 years?

While you are working on that, let us give you a musical demonstration. The first year there is only the original cow and her first calf. (Play music to 1, the first bar line). The second year there is the original cow and two calves. (Play music from beginning to 2). The third year there is the original cow and three calves (Music to 3). The fourth year the oldest calf becomes a mother, and we begin a third generation of Narayana's cows (Music to 4). The fifth year we have another mother cow and three new calves (Musik to 5). The sixth year we have four productive cows, four new calves, and a total herd of 13 (Music to 6). The seventh year brings the birth of the first calf of the first calf of the first calf of Narayana's original cow, and the fourth generation begins (Music to 7). In the eighth year the herd, which went from 1 to 2 to 3 to 4 to 6 to 9 to 13 to 19, now jumps to 28 (Music to 8). In the ninth year, 13 new calves are born. One is a daughter of the original cow, six are granddaughters, and six are great-granddaughters (Musik to 9). In the tenth year, the herd of 41 grows to 60, and the fifth generation begins on a new note (Music to 10). In the eleventh year an additional 28 calves are produced by 28 mothers, and 32 other calves are waiting to become mothers, making a total of 88 (Music to 11). In the twelfth year, Narayaria's herd continues its population explosion, growing from 88 to 129, and registering an annual population growth of 46.59% (Music to 12). In the thirteenth year, the rate drops very slightly to 46.51% as the sixth generation begins (Music to 13). The fourteenth year brings 88 new calves, advancing the herd from 189 to 277 (Music to 14). By the fifteenth year the herd numbers 406. This includes the original cow, 15 daughters, 78 granddaughters, 165 great-granddaughters, 126 great-great-granddaughters, and 21 great-great-great-granddaughters (Music to 15). In the sixteenth year, we have one new daughter, 13 new granddaughters, 55 new great-granddaughters, 84 new great-great-granddaughters, 35 new great-great-great-granddaughters, and the very first great-great-great-great-grand-daughter (Music to 16). Now we arrive at the seventeenth and final year of the problem. Most of you have probably already calculated what the population has to be now, but if you haven't, or if you want to check your work, you can always just count the notes as we play (Music from beginning to end).

