

Explaining the Evolution of Lactase

Scientists have proposed several hypotheses to explain patterns of lactase persistence. Collecting evidence helps them compare the hypotheses. In this portion of the activity, your group will first read descriptions of two of the hypotheses. You will then analyze data and decide whether the data favor one of the hypotheses.

Culture-Historical Hypothesis

Some cultures have a tradition of herding and milking cows, goats, or camels. Cultures that rely on livestock for meat and milk are called “pastoralist.” The **culture-historical hypothesis** says that individuals who are lactase persistent had a selective advantage in pastoralist populations. Two scientists separately proposed this hypothesis for the evolution of lactase persistence in humans.

According to this hypothesis, lactase persistent individuals had a higher level of nutrition because they could drink and digest milk. Milk is a high-calorie source of nutrition that is also high in protein. However, some cultures have a large number of individuals who cannot digest lactose. One way to solve this problem is to ferment milk to make cheese. Some cheeses do not have lactose. Yet, the cheese made from fresh milk has about 40 percent fewer calories than fresh milk. So, people who could digest fresh milk could get more calories in their diet than people who ate cheese made from the same amount of milk. Another possibility is that lactase persistent individuals had an advantage because they were able to take in water from the milk. Milk is an important source of liquid, especially in desert regions.

A higher level of nutrition meant that lactase persistent individuals had higher rates of survival and reproduction or had more children who survived and reproduced. Scientists collected data in Africa to test this hypothesis. They examined different groups of people and determined two things. First, they measured the level of lactase persistence in the group. Second, they estimated the level of pastoralism. The culture-historical hypothesis would be supported if populations that have high levels of lactase persistence had high levels of pastoralism historically. Populations that kept livestock but did not milk them would be expected to show low levels of lactase persistence.

Calcium-Absorption Hypothesis

The second hypothesis suggests a different selective advantage for lactase persistent individuals. Understanding this advantage of fresh milk involves knowing something about calcium. This hypothesis is called the **calcium-absorption hypothesis**. Calcium is a vital mineral that supports the structure of our bones and teeth. It's required for muscle contractions and many other functions. Vitamin D helps the body absorb calcium. Today, vitamin D is added to common foods like milk, bread, and cereal because it's so important. However, human diets do not always include foods that are high in vitamin D. Humans *can* make their own vitamin D when ultraviolet (UV) light penetrates their skin.

People who do not get enough calcium or vitamin D can develop rickets, which leads to improper bone growth (Figure 1). Women whose pelvis has been deformed by rickets may not survive the process of childbirth. *This means that women with vitamin D or calcium deficiency may have relatively fewer children.*

Figure 1. X-ray showing bone deformities associated with rickets.



Image courtesy of Michael L. Richardson, M.D.,
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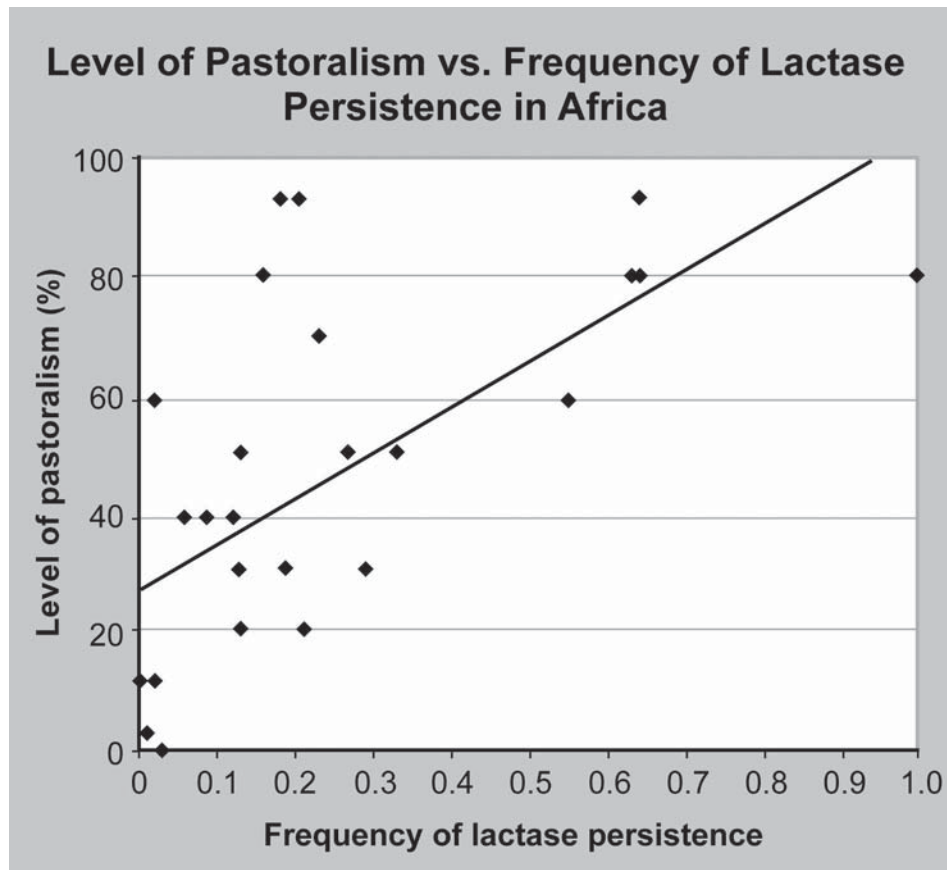
Fresh milk has a high lactose content. Some studies suggest that lactose also helps the body absorb calcium. Calcium is also present in milk. The calcium-absorption hypothesis suggests that people who could digest lactose had an advantage in environments with limited UV light. Digesting lactose also helped these individuals absorb calcium. Without the lactose, these people would have a problem absorbing calcium because of their low levels of vitamin D. Different types of evidence may support this hypothesis. For example, there should be high levels of lactase persistence in areas that have low amounts of UV at certain times of the year. There should also be evidence showing that rickets was common in the past.

Data from Africa

Question

Do the data in Figure 1 support one of the hypotheses for the evolution of lactase persistence?

Figure 1. Graph showing the relationship between the levels of pastoralism and the frequency of lactase persistence in Africa. A high level of pastoralism means that a culture used livestock for meat and milk.



Source: Data from P. Gerbault et al. 2009. Impact of selection and demography on the diffusion of lactase persistence. *PLoS ONE*, 4(7): e6369. doi:10.1371/journal.pone.0006369.