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Rachel Carson Center for Environment and Society  
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David Matuskey

## **Erythroxylum Coca and Its Discontents: A Neurohistorical Case Study of Cocaine, Pleasure, and Empires**

Social hierarchy is a fundamental characteristic of all civilizations. In societies with sufficient capital, this basic imperative has translated into empires that have spanned the globe and all of known history. This drive for rule and domination of people and resources has been well studied in historical and cultural dimensions, but the near ubiquitous formation of empires points to a possible biological correlate that has been decidedly less examined. Any biological intermediary that would be a good candidate for the birth of empires must be linked with rudimentary physiologic processes, a final common pathway of social hierarchy. This pathway, I postulate, is pleasure.

The magnitude and trajectory of history makes a carefully controlled experiment to investigate the biological effects of pleasure and social hierarchy on empires unattainable, but one possible way forward would be to track a known physiological agent in history with the growth of an empire in a case study. Because the biological effects would be well established, this example could provide a proxy to view the more dynamic interactions and symbiosis of the bio-socio-historical effects of empires. One of the best examples of such from history is the story of coca.

In appearance, *Erythroxylum coca* is remarkably forgettable. The leaves have an oval shape with a slightly glossy, longitudinal curve towards the tip. The bush is evergreen and grows to a height of two to five meters in the wild. If it were a plant by another name, one without the involved history of its most famous product, cocaine, it would be largely indiscernible to society.

Despite this innocuous appearance, people first became interested in the plant because of its unique physiology. Coca has hundreds of natural compounds known as alkaloids, which are employed for various functions, including protection against harmful insects that could damage the plant. One of these alkaloids is cocaine. While only one percent of the total makeup of the plant, cocaine functions as a natural pesticide (Nathanson et al. 1993). Like caffeine and nicotine, in all likelihood the effects on humans are an unintended side effect of plant evolution.

The effects of coca on humans were most likely felt for the first time on the eastern slopes of the Andes, where it grows indigenously. Due to lack of written history, the date when coca was first domesticated is a matter of speculation, but there is evidence of coca use dating back to 8000 BCE in Peru (Dillehay et al. 2010). Later, from the period 100–800 CE, there are ceramics and paintings from the pre-Incan Moche civilization depicting coca use. Other evidence of coca's widespread use can be found linguistically, with no better example available than the word coca itself. The word *khoka* in the pre-Incan language Tiwanaku is usually translated as “plant” but might well be better understood as “The Plant.” Its importance was reflected in both spiritual use and the mundane: wads of leaves were used as a measure of time and distance (i.e. one wad of leaves = 45 min or 2–3 kilometers) (Streatfeild 2003).

There was a good reason for the central axis of “Mama Coca.” The Andes are a difficult habitat to live in. The high altitude and rocky soil lead to fatigue and malnutrition. Coca use increases with altitude in South America and the plant is widely used for altitude sickness, probably due to its sympathomimetic effects, such as increased heart rate and dilated bronchioles for easier breathing (Hanna and Hornick 1977). Nutritionally, it has also been found to have high levels of iron, calcium, and some vitamins, possibly the highest such values in the pre-Columbian diet (Duke, Aulik, and Plowman 1975). It is the other effects, however, including mild stimulant properties and suppression of hunger, thirst, pain, and fatigue, that gathered so much interest from the empires.

The first empire to fully integrate coca was the Incan. There is some debate as to how coca was distributed amongst its citizens—one possibility theorizes the upper class had an “exclusive right to chew coca leaves” (Mortimer 1901), while others suggest the use was democratic (Karch 1997). Written history makes clear that coca use was widespread enough in South America that by the time Amerigo Vespucci arrived in northern Brazil (1504) he “discovered” coca use there. It is also clear that coca use skyrocketed after the Spanish arrived, which warrants a closer examination of bio-socio-historical interest.

Initially, the Spanish Empire did not approve of coca as the church was not in favor of its use. This changed once it was realized that much more labor could be extracted from the indigenous workforce when they used coca. This helped in the new mine of Potosí, doubly famous for having the most silver as well as being the highest city in the

empire. The coca was thus used in similar ways as when it was first cultivated for altitude sickness, fatigue, and appetite suppression. In the harsh new reality of the high mines, though, the leaf was given a purely industrial function: more leaf equaled more profit. Furthermore, the indigenous populations did not rebel against this commodification of their previously sacred substance, in some cases even demanding to be paid in coca. This reliance could be attributed to various mechanisms, including prior cultural use (perhaps the collapse of the old social order allowed the general masses to indulge in the fruit of the riches), dependence (less likely, as the low concentration of cocaine was probably not strong enough for dependence as we now define it), and an interesting neurohistorical postulate: that after the collapse of their native culture and subjugation by foreigners this was a way to extract some pleasure in life. Granted, the coca leaf is not the best vehicle for this, but in the dreary wake of the conquistadors even a one percent increase in pleasure would be welcome.

Humans, indeed all mammals, are governed to some degree by the search for pleasure. This is governed by the basic neurophysiology of the reward pathway. This pathway lies deep in the brain, in areas phylogenetically ancient and important long before consciousness. This drive for pleasure allowed for the shaping of generally productive behavior in evolution by rewarding behaviors such as sex, eating, and social bonding. In primeval habitats, however, this physiology could be quite miserly in its design, allowing only fleeting glimpses of euphoria in the gritty business of survival.

This changed when empires became industrialized in the late 1800s. Now sufficiently sophisticated, society had the technological ability to isolate compounds from the natural world. It is of little wonder that this new hunt focused on pleasure. Europe soon released cocaine from its high altitude and low concentration, and newly formed patent medicines (such as Coca-Cola) opened an avenue to the middle and lower class consumer markets (Gootenberg 2002). Popularizers such as Sigmund Freud and Pope Leo XIII soon helped cocaine become the most profitable single pharmaceutical line for companies such as Merck in Germany (Gootenberg 2009).

What had started out as a treatment for toothaches, hay fever, and other ailments (morphine addiction being of the more interesting) became a tool in the pursuit of a new and improved personal pleasure. All of this happened within the changing social structure of the modern era that was becoming more abstract and losing the tight

social cohesion of yesteryear. This new pursuit had the potential to be dangerous for all, but probably most dangerous for those on the bottom: the demoralized and those with low social status.

From this view, the “epidemic” of crack cocaine a hundred years later in the 1980s can be seen as the result of a progression of the cocktail of pleasure, chemicals, and status that had been brewing for hundreds of years—an even more potent combination of increased pharmacologic action with a tenuous social brake.

While we are left to infer this theoretical relationship between cocaine and hierarchy on historical grounds, modern animal research literature provides some possible mechanistic insight. For example, a study by Czoty et al. (2004) focused on the social order among primates given unlimited access to cocaine. Once addicted, these primates destroyed their previous social hierarchy and the new order that formed was truly egalitarian; all were subservient to cocaine with no differences amongst themselves. The dopamine reward pathway mirrored these changes. Namely: higher status animals had more dopamine, a neurochemical associated with pleasure, than their lower counterparts until they became sufficiently addicted; at that point they all had similarly low levels of dopamine.

This short essay is intended as an exploration of how seemingly divergent disciplines could unite to offer a more definitive explanation of the complex story of coca and empires. But even this brief discussion shows how neuroscience can provide a deeper understanding of historical truths through the example of coca, the pleasure pathway, and social status within empires. Convergences such as these help increase our understanding of the constellation of neurophysiology, culture, and environment that make up our history.

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