

## The Krebs Cycle

### WILEY COYOTES

Death goes hand in hand with life on a livestock farm. Before he turned five, Ian Henderson had seen his dad kill the male lambs for the table. But staring out over his station—the grazing ground of South Australia, the farm that was his now—he dreaded what he knew he'd find: the bodies of the sheep that were his livelihood, their throats and bellies torn out, their meat and fleeces useless.

Packs of wild dingo dogs had arrived in the early spring and taken out the lambs first—this year's meat and next year's wool. Then they started in on the ewes whose fleeces he was planning to sell. Henderson and three of his hired hands guarded the night pasture with rifles in hand; but you can't keep sheep penned up in the daytime, and you can't be everywhere at once. He'd left out poisoned meat and even poisoned an already-killed sheep; the dingoes ignored it. He'd set spring-traps powerful enough to snap a human leg; the dingoes strolled around them. His own dogs were good at herding sheep but no match for the vicious packs. Every night one or two fewer sheep came in; every day he found another corpse.

What was to keep the wild dogs from coming back till every one of his sheep—each worth a thousand or more—was dead? He began going into town more often for a drink, and then for two drinks, and then for five. Grief and rage boiled up in him. He poured more whiskey on top of it. The man at the other end of the bar said, "You seem thirsty, mate," in a deep mild voice.

Henderson had always believed that a man doesn't talk about his troubles, but what did he have to lose? The stranger sipped his beer, silent till Henderson stopped talking. Then he reached into his pocket and pulled out a small card. DINGO DESTROYER, it said, and a phone number. "Call him," the stranger said, and took another sip of beer.

The Dingo Destroyer pulled up in a battered truck three days later at sundown: a short, scruffy, balding man with a dufflebag over his shoulder. Henderson's heart sank. The man waved away his explanations and followed Henderson to the night pasture, where he opened his bag and began fastening collars around the thick, woolly necks of the sheep. Henderson opened his mouth to speak. "Fluoroacetate," the Dingo Destroyer said. "Poison."

"I tried poison."

The Dingo Destroyer ignored him. When all the sheep had collars—they were long, wide plastic packets, made to fasten—he said, "You been keeping a guard at night?"

"What do you think?"

"Don't do it tonight. Leave them out."

"You're crazy. You're—" But the little man



was already walking back to his truck. Henderson watched him drive off. He went back to the house. He told the hired hands to go on home; they looked at him like he was the crazy one. He went to bed early and lay there all night.

At dawn, all the sheep but five were dead, their throats torn out.

The stupid, worthless packets around what had been their necks were empty. Henderson thought he might pass out; he thought he might scream. He would find that—curses flew from his mouth—and do to him what he'd done to his sheep, corpse after corpse—

He stopped. The dead, stiff body at his feet wasn't a sheep; it was a dingo. So was the one in the corner. So was the one he had stepped right over, not even recognizing it, on the way into the pasture. Henderson counted twenty-two of the dead wild dogs. Looking at the five sheep left alive, huddled in the corner of the pasture, Henderson's rage turned into violent joy: his enemies were dead! Breathing hard, he gave the nearest tan body a furious kick. Then his eyes went to the five sheep that remained to him, and both rage and joy subsided into relief. He could start again.



### Scientific Connection

Cellular respiration and farming have a lot in common. The goal of farming is to harvest something (corn, wheat, wool, etc.) so it can be sold for a profit. A large harvest will result in a gigantic profit and a thriving farm, while a poor harvest will result in a scant profit and a bankrupt farm. Believe it or not, the mitochondria in the cells of your body harvest electrons, so that they can be sold for energetic profit in the form of ATP.

You consume meat and vegetables that are purchased from farms. Your digestive system reduces these foods into simple nutrient molecules (simple sugars, fatty acids, amino acids) and absorbs them into your blood. The blood in turn carries these nutrients to the hardworking cells of your body. The mitochondria in these cells harvest electrons from the nutrients through a series of sequential oxidation reactions known as the Krebs cycle. The purpose of the Krebs cycle is to steal as many electrons from each nutrient as possible until all that remains is a completely oxidized product (carbon dioxide), which you breathe out. The more electrons a nutrient has, the richer the ATP harvest. Fats are loaded with electrons and more ATP can be made from them than an equal mass of sugar.

In order to be “harvested”, nutrient molecules must first be chemically converted into one of the intermediates of the Krebs cycle (Acetyl-

CoA, Oxaloacetate, Citrate, Isocitrate,  $\alpha$ -ketoglutarate, Succinyl-CoA, Succinate, Fumarate, or Malate). The electrons taken from these intermediates are then whisked away by electron carriers (NADH, FADH<sub>2</sub>) and passed down the electron transport chain until they are finally accepted by oxygen. The passage of electrons through the electron transport chain generates the proton gradient necessary to power ATP synthase, the enzyme responsible for generating ATP from ADP and phosphate (ADP + phosphate  $\rightarrow$  ATP). In short, the more electrons you can harvest the more ATP you can make. If your cells make a continuous supply of ATP they will continue to live; however, if their rate of ATP production crashes they will die and so will you.

Fluoroacetate is a gigantic monkey wrench that gets thrown into the Krebs cycle and shuts it down hard. Inhibiting the Krebs cycle prevents electrons from being harvested. As a result, the other events involved in cellular respiration cannot occur and ATP production comes to a halt resulting in rapid cellular death. Fluoroacetate is metabolized to fluoroacetyl-CoA, which bears a striking resemblance to acetyl-CoA, a normal Krebs cycle intermediate. Fluoroacetyl-CoA is converted into fluorocitrate, which acts as a powerful inhibitor of, aconitase, the enzyme responsible for the conversion of citrate to isocitrate. The inhibition of aconitase stops the progression of the Krebs cycle and the rate of ATP production decreases to fatal levels. Fluoroacetate is a phenomenally effective killing agent and is widely considered to be one of the most toxic substances in existence. It is primarily used as a pesticide, especially against wild dogs. Wild dogs like to bite the throats of sheep; as a result sheep are often given collars filled with fluoroacetate that cover their necks. Any wild dog foolish enough to bite one of these sheep will receive a lethal dose of fluoroacetate that will halt ATP production in nearly every cell of its body, resulting in certain death.

↪ **Take Home Message** ◀

**Inhibition of the Krebs Cycle can lead to fatal decreases in ATP production.**