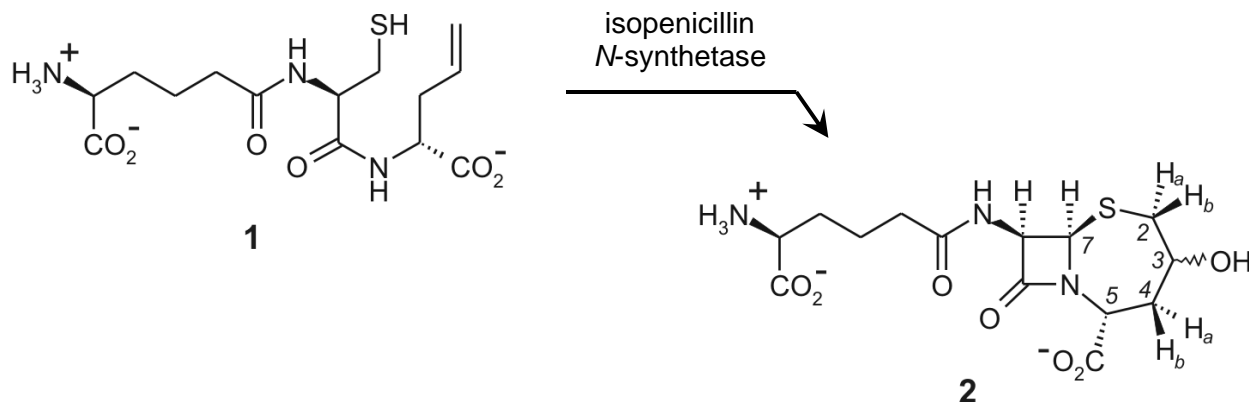


**In-Class Exercise:
Spatial Relationships and 1D NOE**

In the presence of the enzyme isopenicillin *N*-synthetase, the model substrate **1** is converted stereoselectively to a product **2** with unknown stereochemistry at position 3.



It was not possible to assign position 3 by coupling constants, so a one-dimensional nuclear Overhauser effect (1D NOE) experiment was performed on product **2**. The next page shows an ordinary ^1H NMR spectrum of **2** at the bottom, and then two NOE difference spectra—one with excitation at $\delta = 2.67$ ppm (H_{2a}), and the other with excitation at $\delta = 2.20$ ppm (H_{4b}).

- Using arrows on the substructures on the next page, show how excitation energy is transferred from irradiated protons to other spins in the molecule.
- Based on this information, assign stereochemistry to the proton and hydroxyl group attached to carbon 3.

