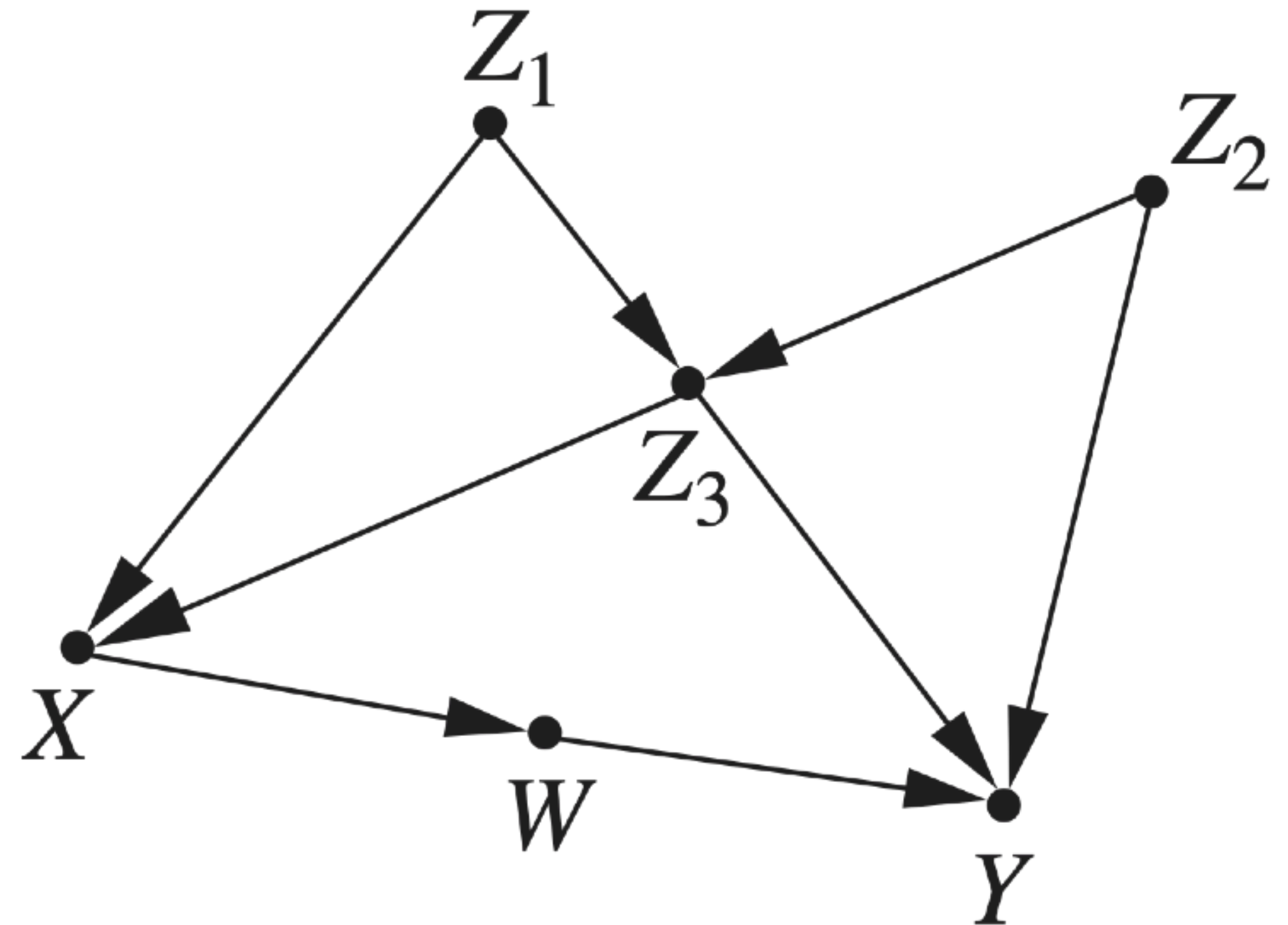


# Open and closed paths

- Paths containing uncontrolled pipes and forks are open
- Paths containing colliders are closed by default, but open if we condition on the collider
- To estimate the true causal effect of  $x$  on  $y$ , we need all non-causal paths from  $x$  to  $y$  to be closed in our model

Identify all the open paths from  $X$  to  $Y$



# Back door criterion

To estimate the causal effect of  $X$  on  $Y$ , identify a set of control variables such that no descendants of  $X$  are in the control set, and all paths between  $X$  and  $Y$  that contain an arrow into  $X$  are blocked.