Some terms that must be understood

Microscopic Variable

Macroscopic Variable

<u>Extensive</u> ($\propto N$)	<u>Intensive</u> ($\neq f(N)$)
V volume	P pressure
A area	$\mathcal{S}$ surface tension
L length	$\mathcal{F}$ tension
$\mathcal{P}$ polarization	$\mathcal{E}$ electric field
M magnetization	H magnetic field
$\cdots\cdots\cdots$	$\cdots\cdots\cdots$
	T temperature
U internal energy	

Adiabatic Walls

Diathermic Walls

Equilibrium

Steady State

Complete Specification:

Independent and Dependent Variables

Equation of State

$$PV = NkT$$

$$V = V_0(1 + \alpha T - \mathcal{K}_T P)$$

$$M = cH/(T - T_0) \quad T > T_0$$

In Equilibrium with Each Other

OBSERVATIONAL FACTS

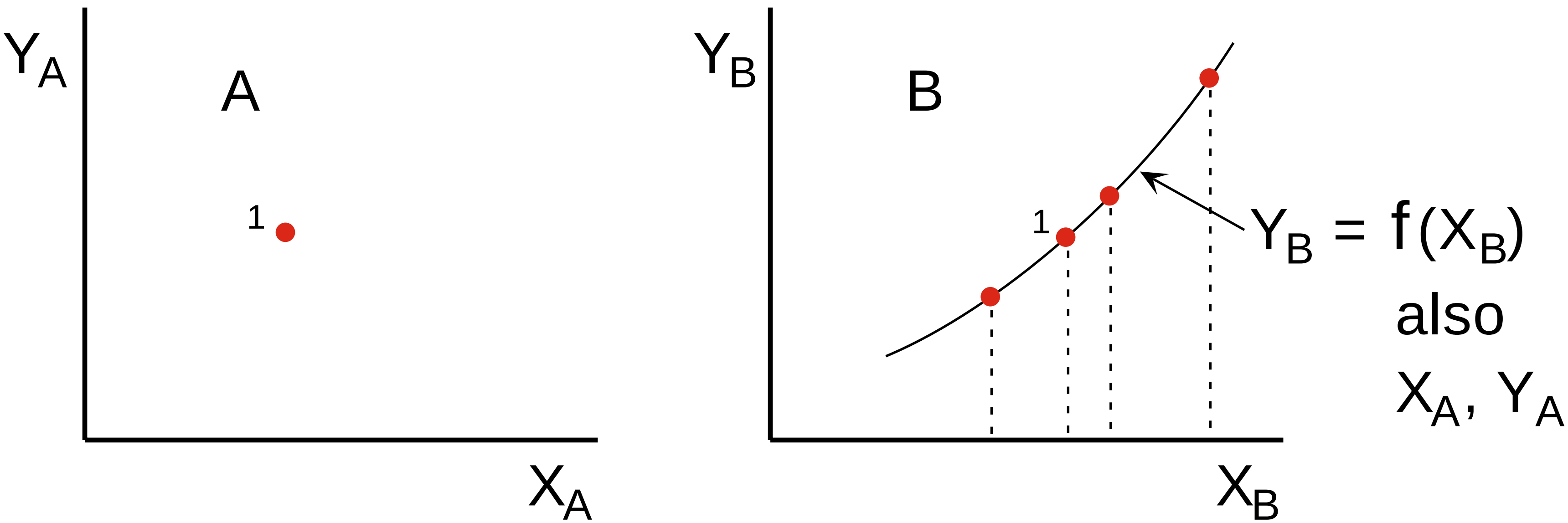
"0^{th} Law"

if $A \overset{\text{equilibrium}}{\longleftrightarrow} C$ and $B \overset{\text{equilibrium}}{\longleftrightarrow} C$

then $A \overset{\text{equilibrium}}{\longleftrightarrow} B$

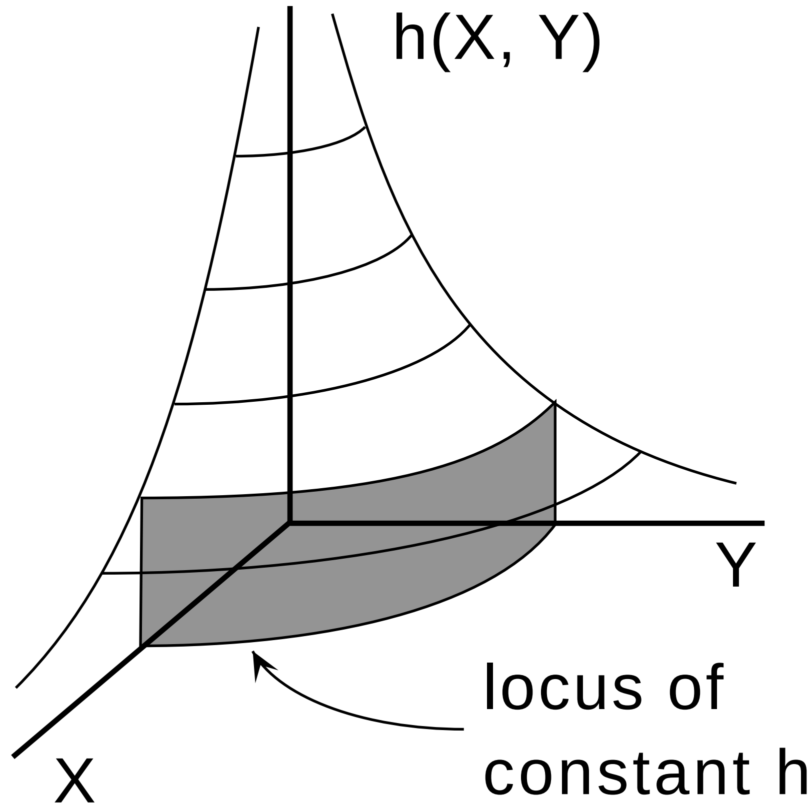
" Law 0.5 ? "

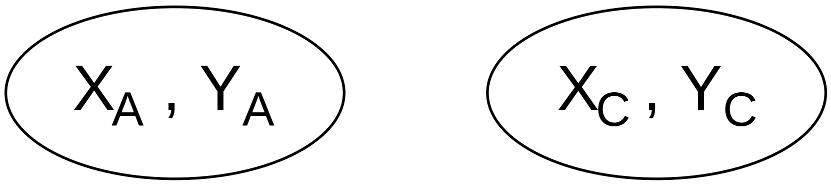
Many macroscopic states of B can be in equilibrium with a given state of A



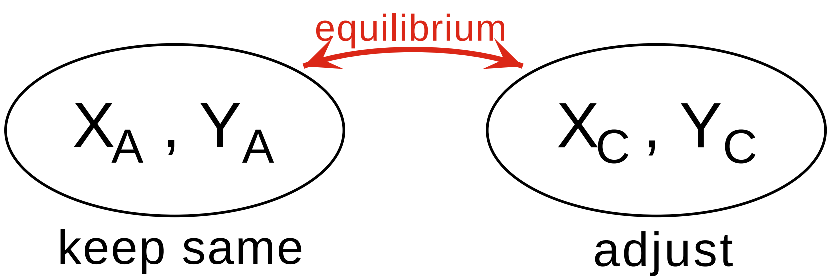
<u>THEOREM</u> A "predictor" of equilibrium h(X, Y, ...) exists

- only in equilibrium
- state variable
- many states, same h
- different systems, different functional forms
- value the same if systems in equilibrium



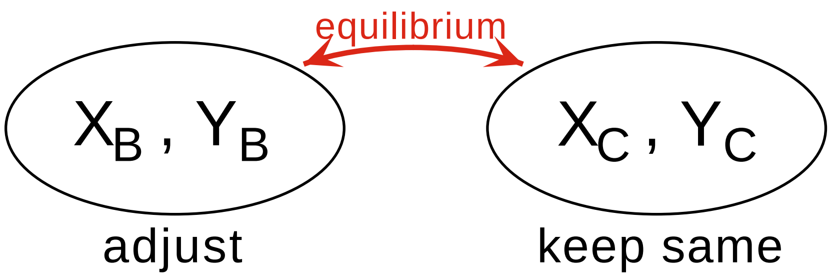


X_A , Y_A , X_C , Y_C all free [P_A , V_A , P_C , V_C]



$X_C = f_1(Y_C, X_A, Y_A)$ [$P_C = P_A V_A / V_C$]

$F_1(X_C, Y_C, X_A, Y_A) = 0$ [$P_C V_C - P_A V_A = 0$]



$$X_B = g(Y_B, X_C, Y_C) \qquad [\, P_B = P_C V_C / V_B \,]$$

$$F_2(X_C, Y_C, X_B, Y_B) = 0 \qquad [\, P_C V_C - P_B V_B = 0 \,]$$

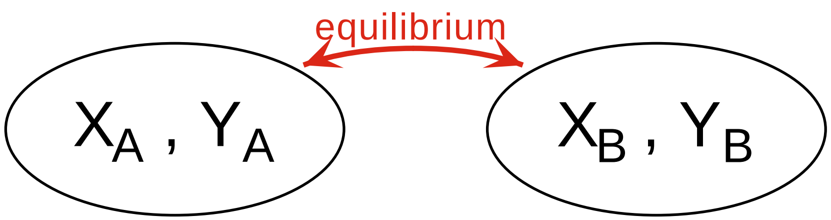
solve for X_C

$$X_C = f_2(Y_C, X_B, Y_B) \qquad [\, P_C = P_B V_B / V_C \,]$$

same value as before

$$f_1(Y_C, X_A, Y_A) = X_C = f_2(Y_C, X_B, Y_B) \quad (1)$$

$$[\, P_A V_A / V_C = P_B V_B / V_C \,]$$



due to 0^{th} law

$$\Rightarrow F_3(X_A, Y_A, X_B, Y_B) = 0 \quad (2)$$

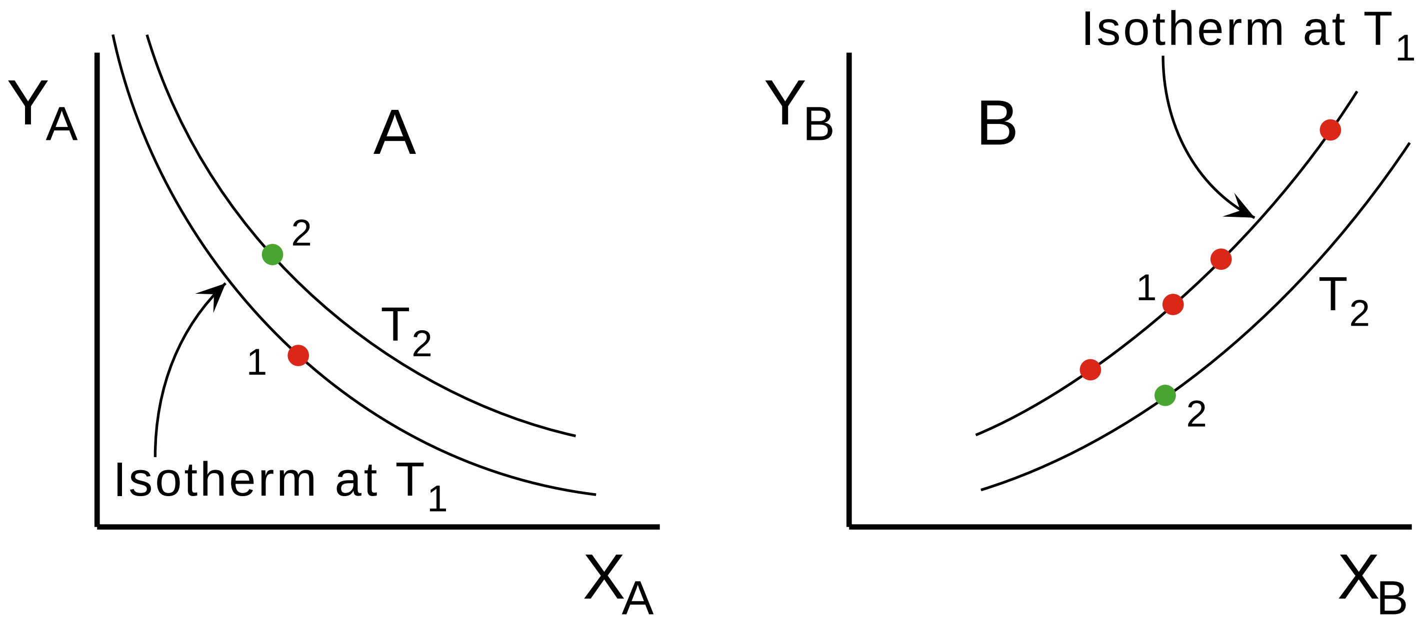
(1) + (2) $\Rightarrow$ F_3 factors

Y_C drops out

For this equilibrium condition

$$h(X_A, Y_A) = \text{constant} = h(X_B, Y_B)$$

$$[\, P_A V_A = P_B V_B \,]$$



Y_A
A
2
T_2
1
Isotherm at T_1
X_A
Y_B
B
Isotherm at T_1
1
T_2
2
X_B