A **Biological model:** STG
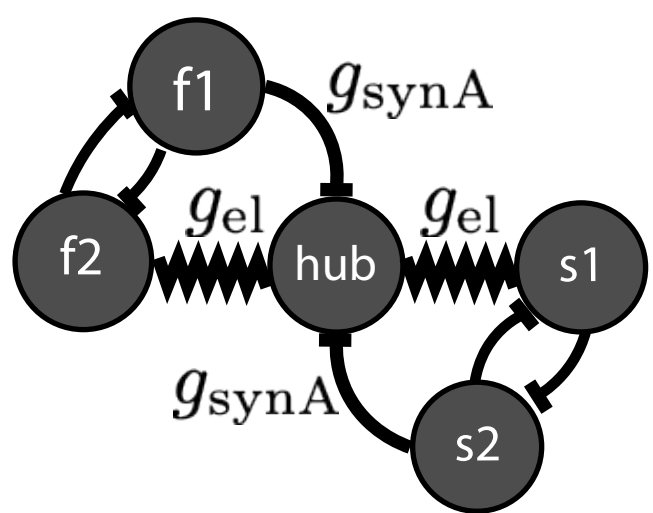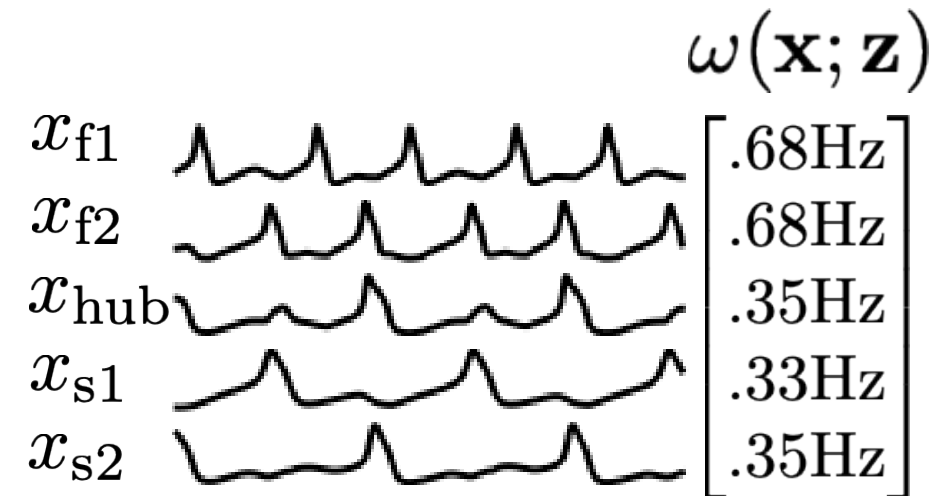
$$\mathbf{z} = \begin{bmatrix} g_{\mathrm{el}} \\ g_{\mathrm{synA}} \end{bmatrix} \quad \mathbf{x} = \begin{bmatrix} x_{\mathrm{f1}} \\ x_{\mathrm{f2}} \\ x_{\mathrm{hub}} \\ x_{\mathrm{s1}} \\ x_{\mathrm{s2}} \end{bmatrix}$$

$$C_m \frac{d\mathbf{x}}{dt} = -h(\mathbf{x}; \mathbf{z}) + d\mathbf{B}$$

B **Emergent property statistic:** spiking frequency

$$\omega(\mathbf{x}; \mathbf{z})$$

$$\begin{matrix} x_{\mathrm{f1}} \\ x_{\mathrm{f2}} \\ x_{\mathrm{hub}} \\ x_{\mathrm{s1}} \\ x_{\mathrm{s2}} \end{matrix} \begin{bmatrix} .68\mathrm{Hz} \\ .68\mathrm{Hz} \\ .35\mathrm{Hz} \\ .33\mathrm{Hz} \\ .35\mathrm{Hz} \end{bmatrix}$$

C **Emergent property:** intermediate hub frequency

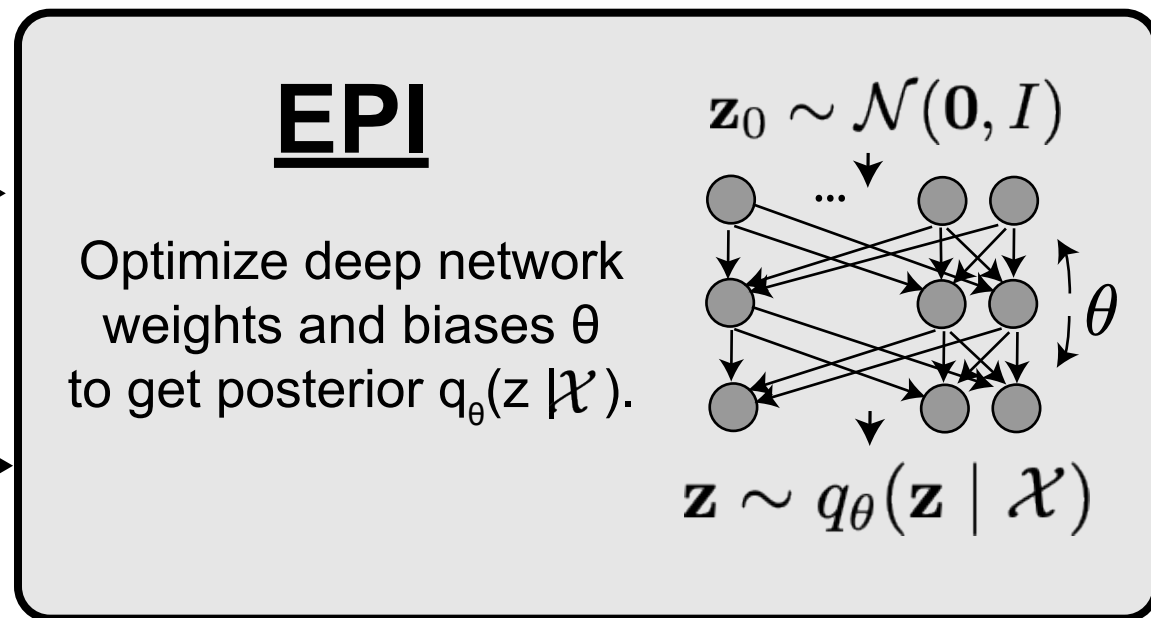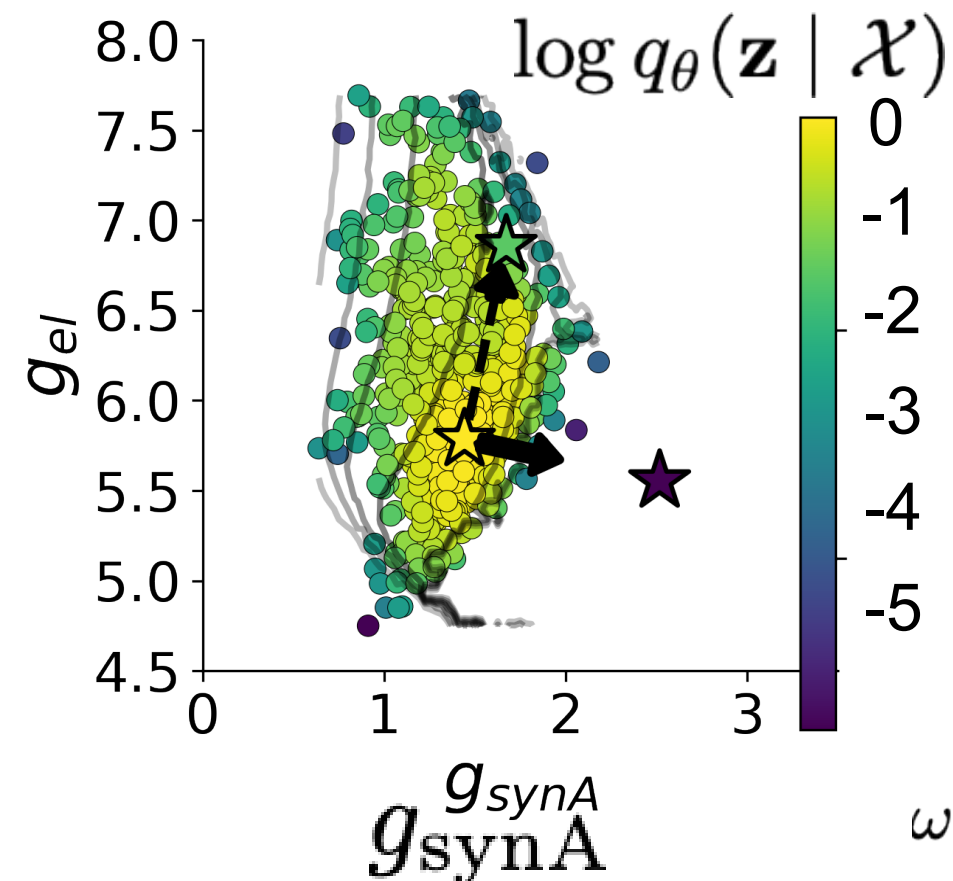$$\mathbb{E}_{\mathbf{z},\mathbf{x}}[\omega_{\mathrm{hub}}(\mathbf{x}; \mathbf{z})] = 0.55\mathrm{Hz}$$

$$\mathrm{Var}_{\mathbf{z},\mathbf{x}}[\omega_{\mathrm{hub}}(\mathbf{x}; \mathbf{z})] = 0.025^2\mathrm{Hz}^2$$

$$x_{\mathrm{hub}}$$

D **Emergent property inference**

biological model

emergent property

EPI

Optimize deep network weights and biases θ to get posterior $q_\theta(z \mid \mathcal{X})$.

$$\mathbf{z}_0 \sim \mathcal{N}(\mathbf{0}, I)$$

$$\theta$$

$$\mathbf{z} \sim q_\theta(\mathbf{z} \mid \mathcal{X})$$

E **EPI posterior**

$$\log q_\theta(\mathbf{z} \mid \mathcal{X})$$

$$g_{\mathrm{el}}$$

$$g_{synA}$$

$$g_{\mathrm{synA}}$$
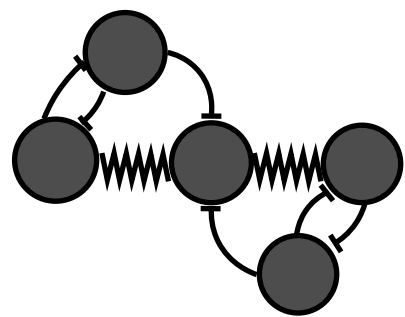
F **Posterior simulations**

$$\omega_{\mathrm{hub}}(\mathbf{x}; \mathbf{z}) \ (\mathrm{Hz})$$

$$\omega_{\mathrm{hub}} = .55\mathrm{Hz} \quad .54\mathrm{Hz} \quad .43\mathrm{Hz}$$