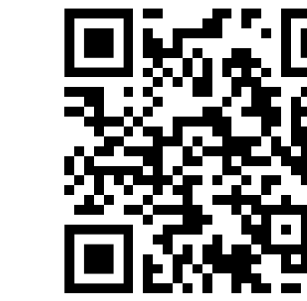


# Legs as linkages and lollipop sticks

Jim Usherwood

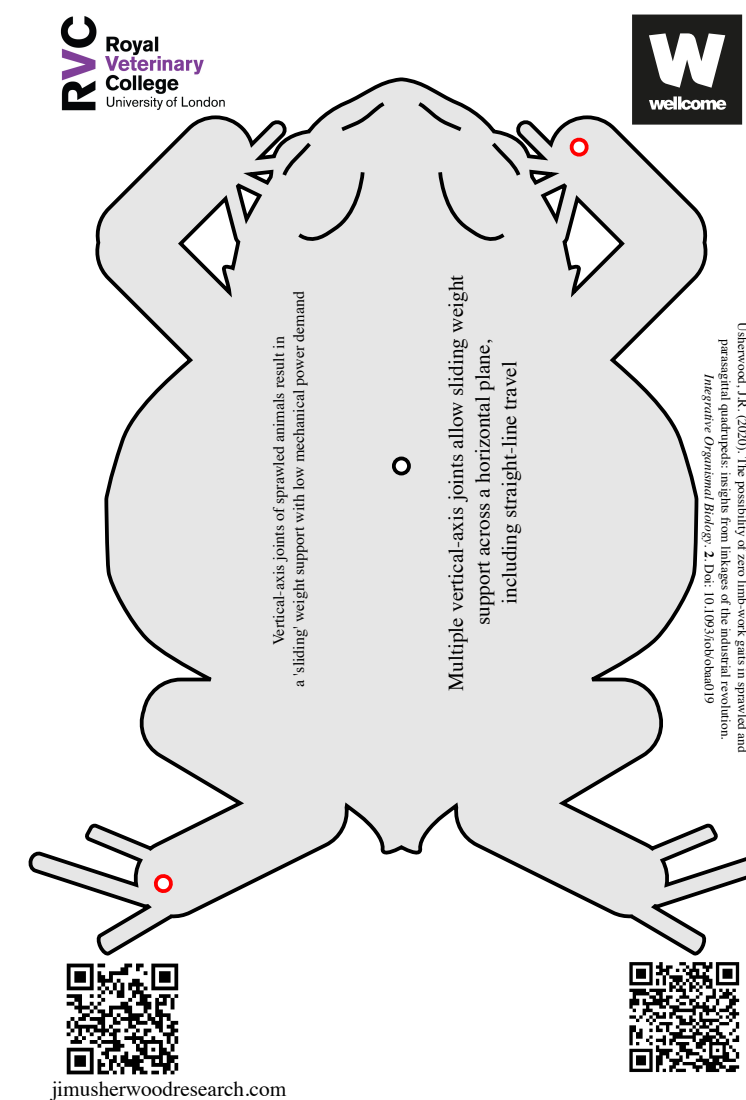
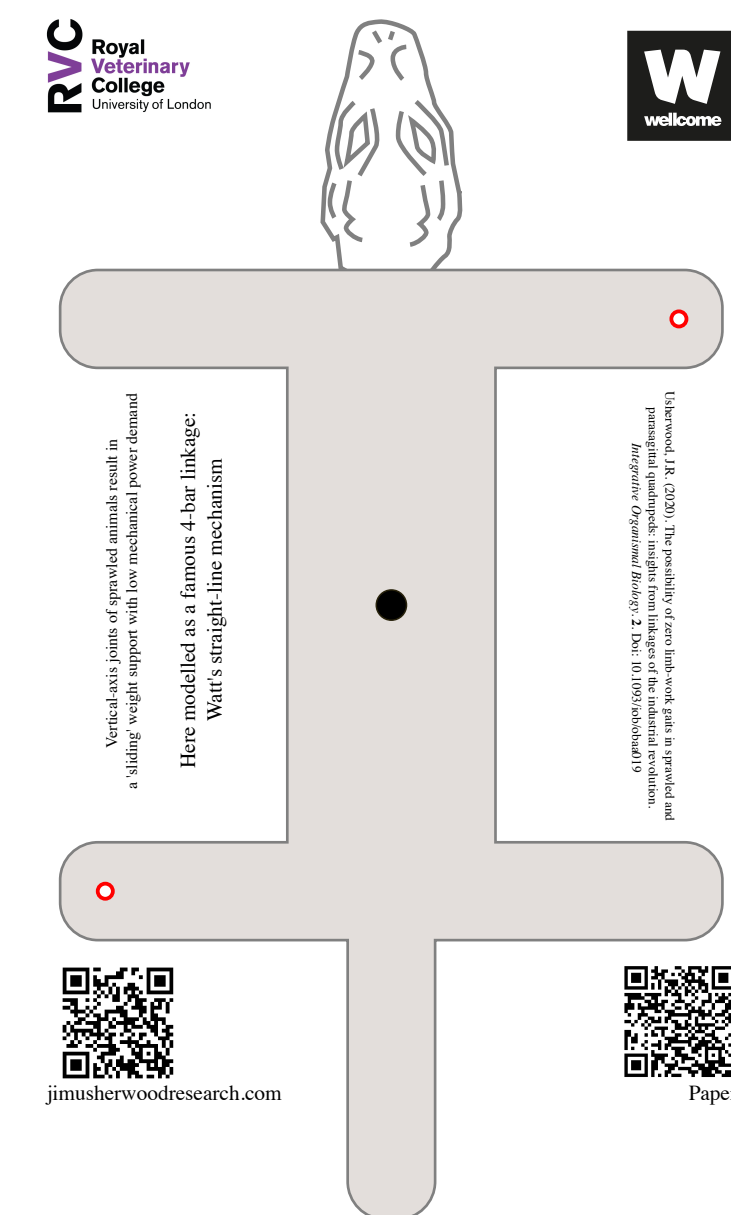
jusherwood@rvc.ac.uk  
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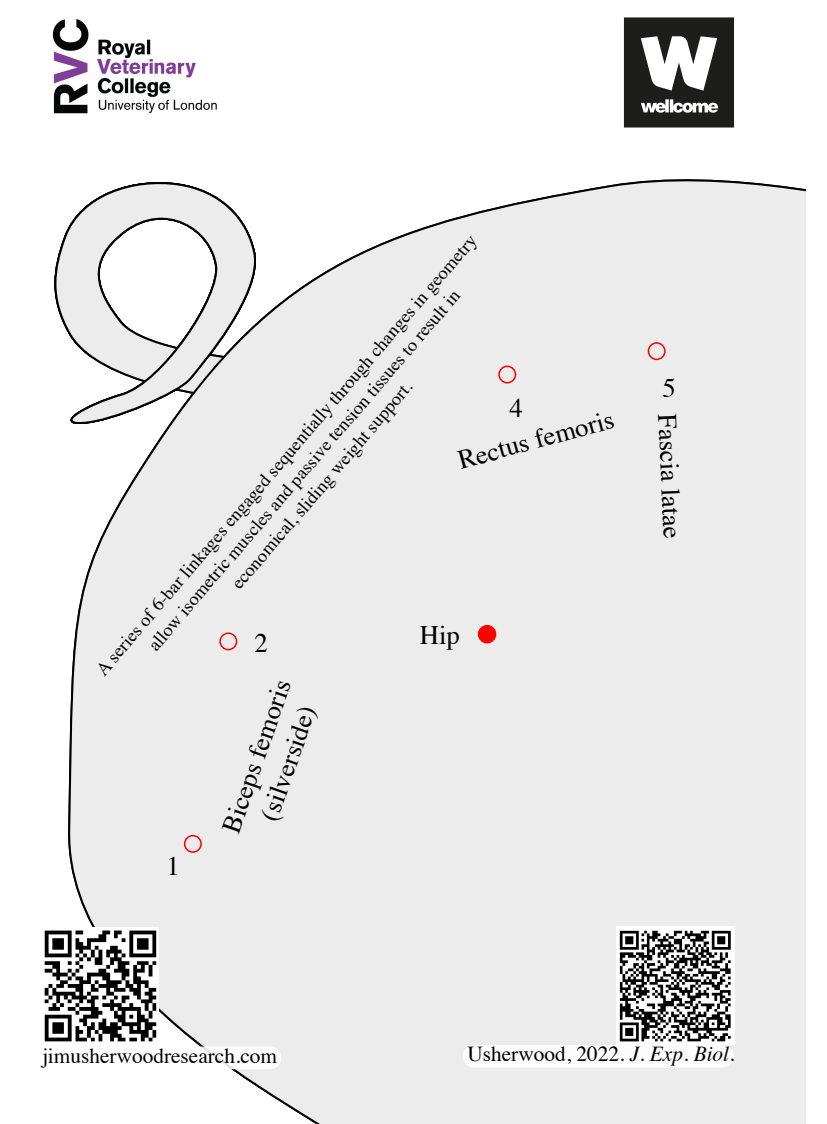
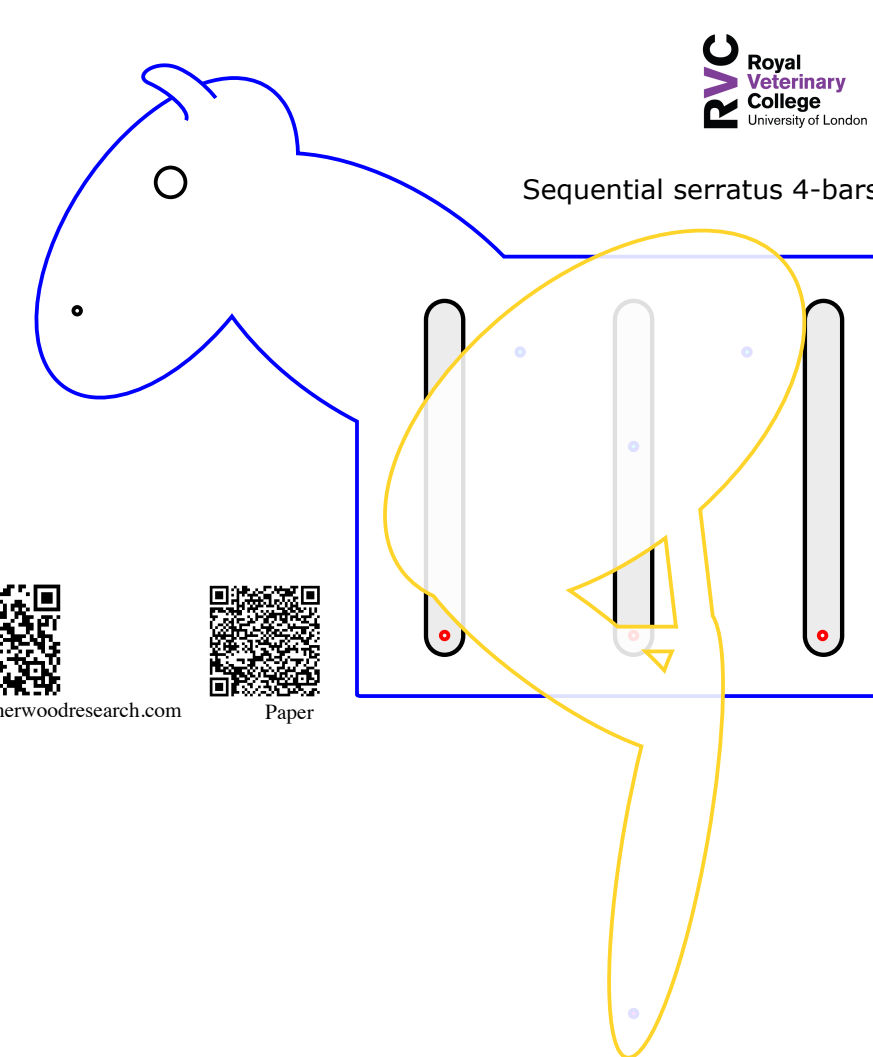
## Legs-as-linkages principles

1. LOW mechanical power **demand** from the leg: keep force perpendicular to velocity.
2. LOW mechanical power **supply** from muscles: keep loaded muscles isometric.
3. SIMPLE control: let changes in geometry load and unload muscles.

Sprawled animals: vertical-axis joints support horizontal motions without power.  
Think of a door swinging on a hinge.

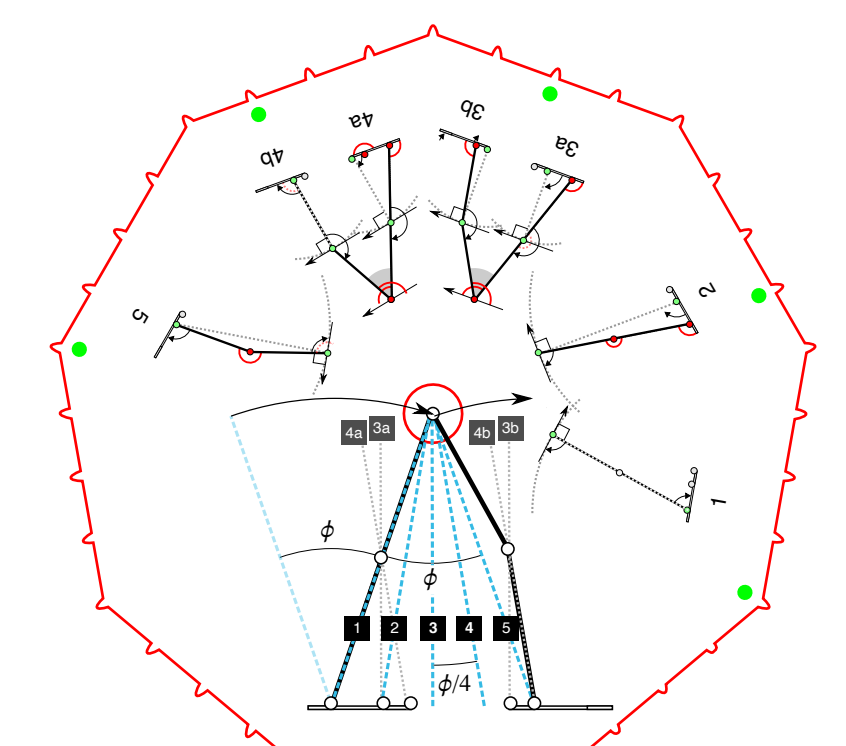
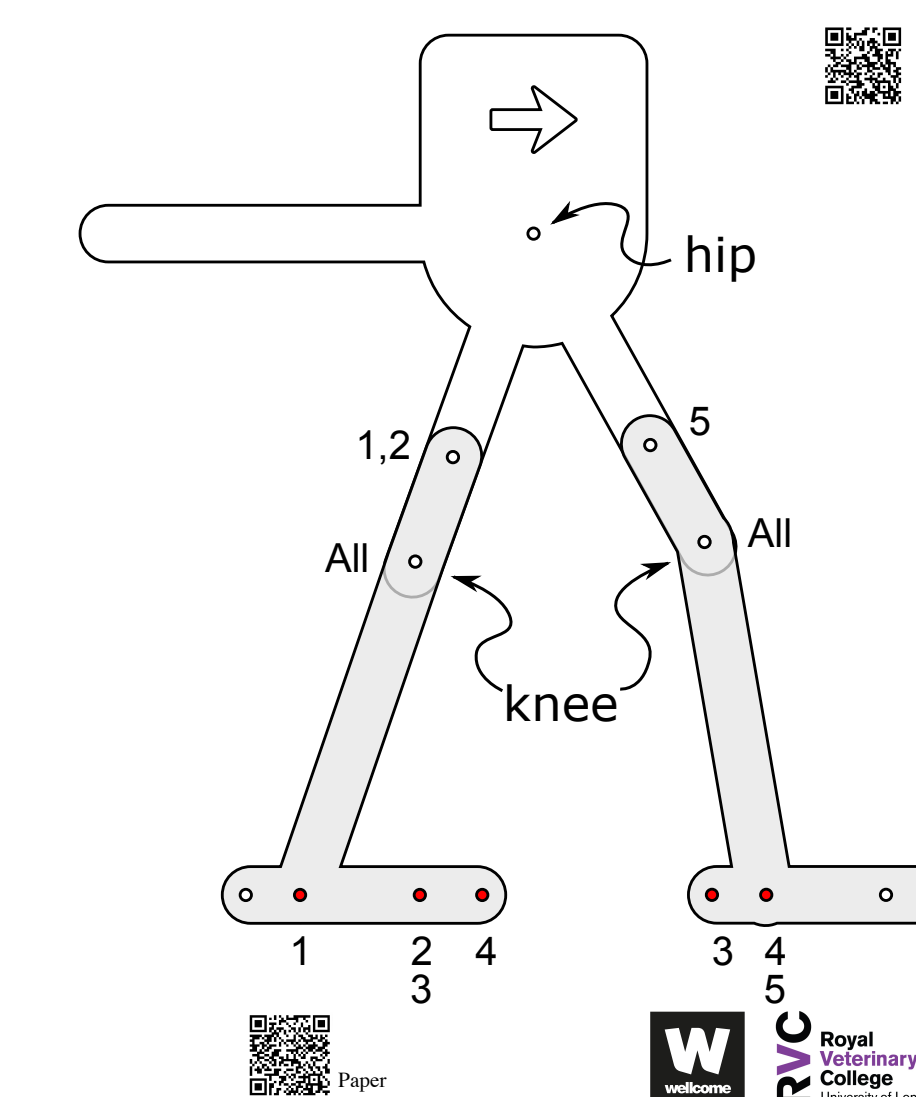
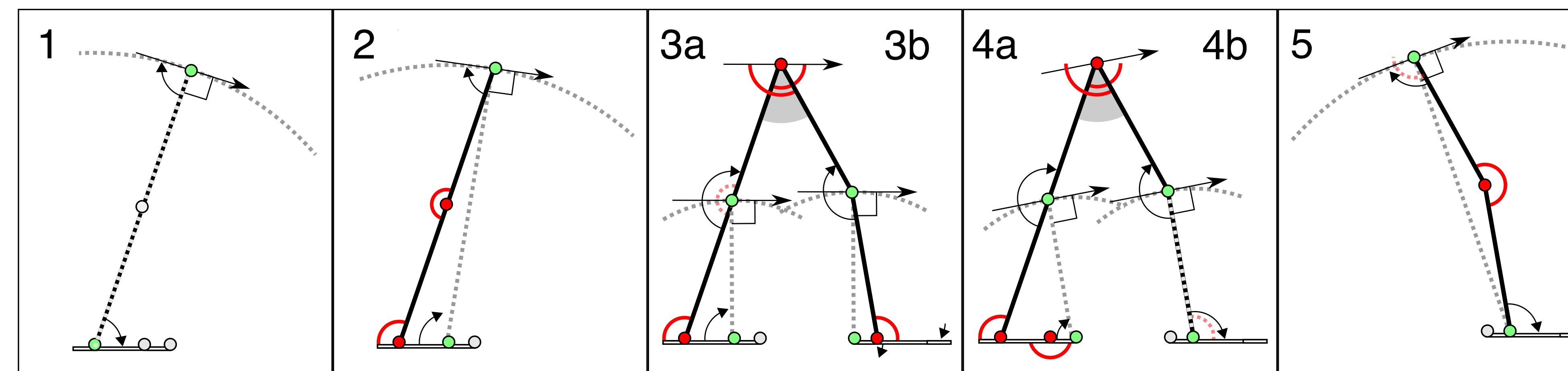
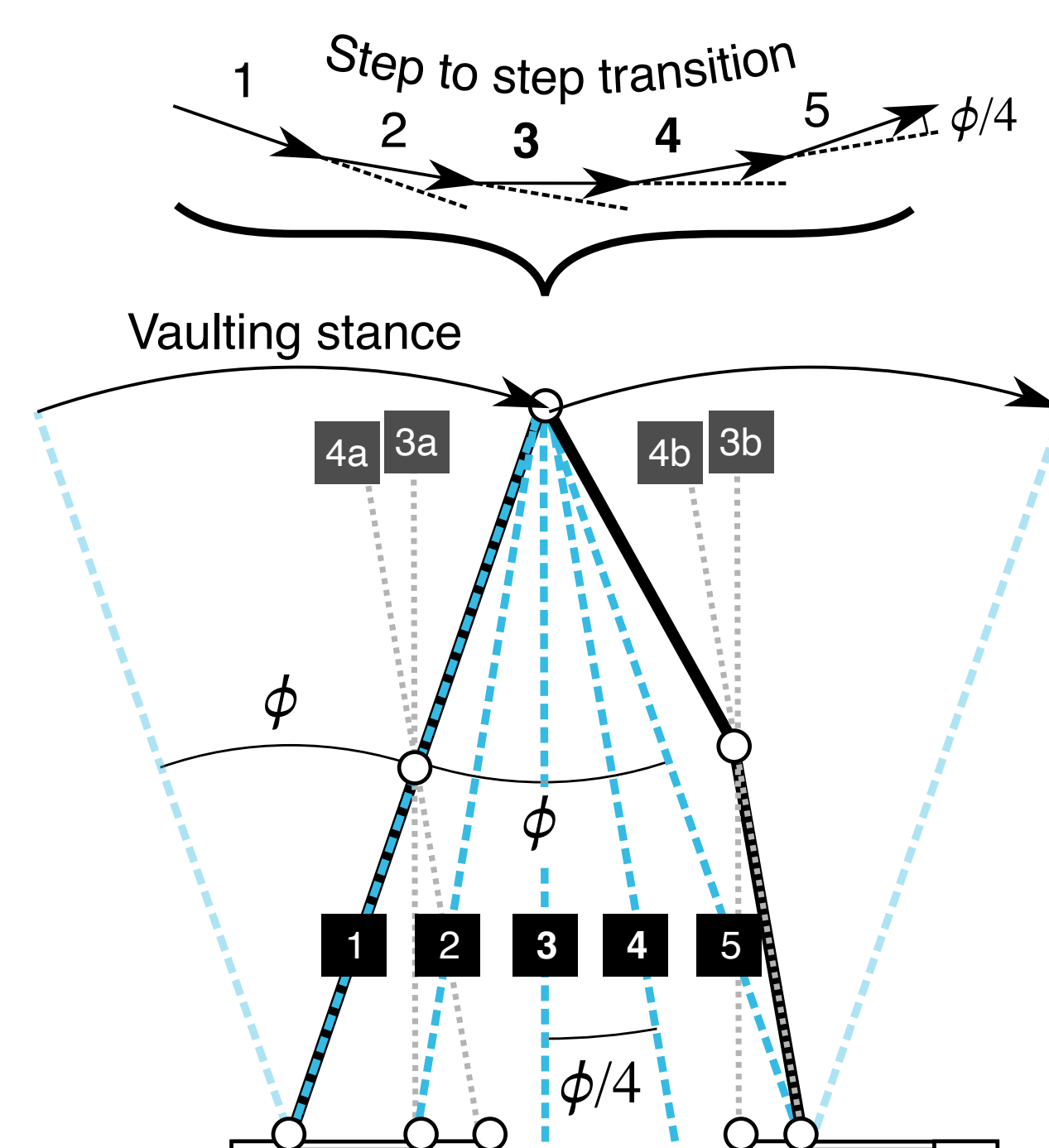


See the 6x4" postcard toys in action and download their plans here:



Upright animals: 4-bar and 6-bar linkages, engaged sequentially through changes in geometry, result in low-power 'sliding' weight support.

Human walking: not only an arcing 'inverted pendulum' stance, but also a 'rolling' step-to-step transition.



Predictions: knee half way down leg; heel:midfoot:toe ratio 1:2:1; step length 2 or 3 foot lengths.

(leaning on the collisional analysis of Ruina, Kuo etc.: minimise work by dividing a change in CoM direction evenly; spread virtual legs (blue, dashed) evenly. Small angle assumptions. No account of energy input (except need not be brief)).