



**Figure S1.** *arg1-2 mar1-1* and *arg1-2 mar2-1* roots and hypocotyls grow in random directions. Dark-grown seedlings (n=19-32) grown on the surface of 30° backward-tilted 1.5% agar-containing GM plates (A). Root (B) and hypocotyl (C) angles relative to the gravity vector were measured and placed into one of 6 bins. The area of each wedge is proportional to the number of plants observed in each 60° bin; the total area for each pie chart is 1 (gray circle). For both roots and hypocotyls, *mar1-1*, *mar2-1*, and Ws grow most frequently within 30° of the vertical, while a higher proportion of *arg1-2* roots and hypocotyls deviates from this range. Double mutants grow randomly.