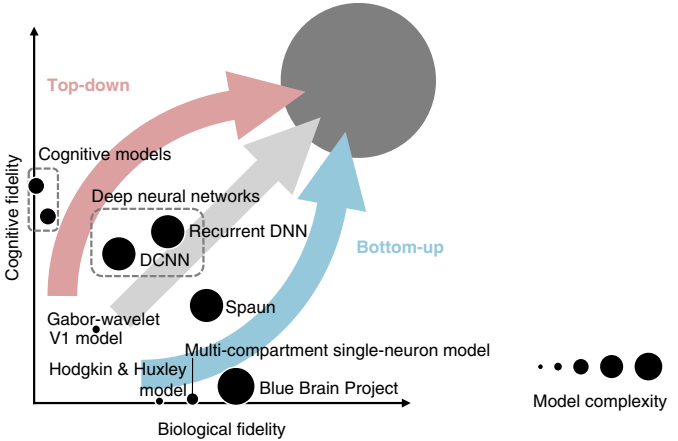

Fig. 3 | The space of process models. Models of the processes taking place in the brain can be defined at different levels of description and can vary in their parametric complexity (dot size) and in their biological (horizontal axis) and cognitive (vertical axis) fidelity. Theoreticians approach modeling with a range of primary goals. The bottom-up approach to modeling (blue arrow) aims first to capture characteristics of biological neural networks, such as action potentials and interactions among multiple compartments of single neurons. This approach disregards cognitive function so as to focus on understanding the emergent dynamics of small parts of the brain, such as cortical columns and areas, and to reproduce biological network phenomena, such as oscillations. The top-down approach (red arrow) aims first to capture cognitive functions at the algorithmic level. This approach disregards the biological implementation so as to focus on decomposing the information processing underlying task performance into its algorithmic components. The two approaches form the extremes of a continuum of paths toward the common goal of explaining how our brains give rise to our minds. Overall, there is tradeoff (negative correlation) between cognitive and biological fidelity. However, the tradeoff can turn into a synergy (positive correlation) when cognitive constraints illuminate biological function and when biology inspires models that explain cognitive feats. Because intelligence requires rich world knowledge, models of human brain information processing will have high parametric complexity (large dot in the upper right corner). Even if models that abstract from biological details can explain task performance, biologically detailed models will still be needed to explain the neurobiological implementation. This diagram is a conceptual cartoon that can help us understand the relationships between models and appreciate their complementary contributions. However, it is not based on quantitative measures of cognitive fidelity, biological fidelity and model complexity. Definitive ways to measure each of the three variables have yet to be developed. Figure inspired by ref. [122].