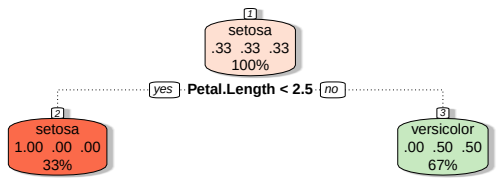
Introduction to Machine Learning

CART: Growing a Tree



Learning goals

- Understand how a tree is grown by an exhaustive search over all possible features and split points
- Know where exactly the split point is set if several yield the same empirical risk

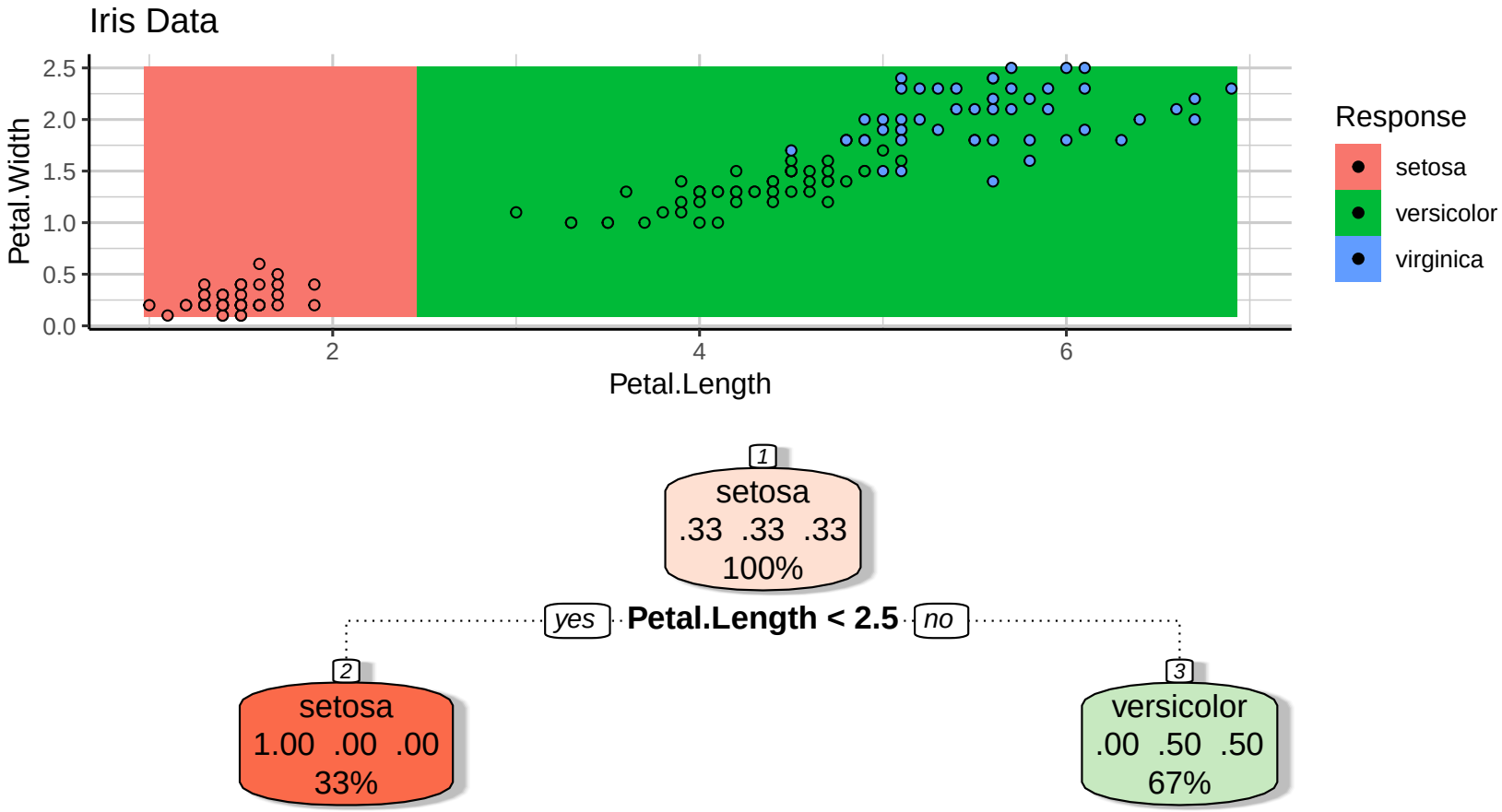
TREE GROWING

We start with an empty tree, a root node that contains all the data. Trees are then grown by recursively applying *greedy* optimization to each node $\mathcal{N}$.

Greedy means we do an **exhaustive search**: All possible splits of $\mathcal{N}$ on all possible points t for all features x_j are compared in terms of their empirical risk $\mathcal{R}(\mathcal{N}, j, t)$.
The training data is then distributed to child nodes according to the optimal split and the procedure is repeated in the child nodes.

TREE GROWING

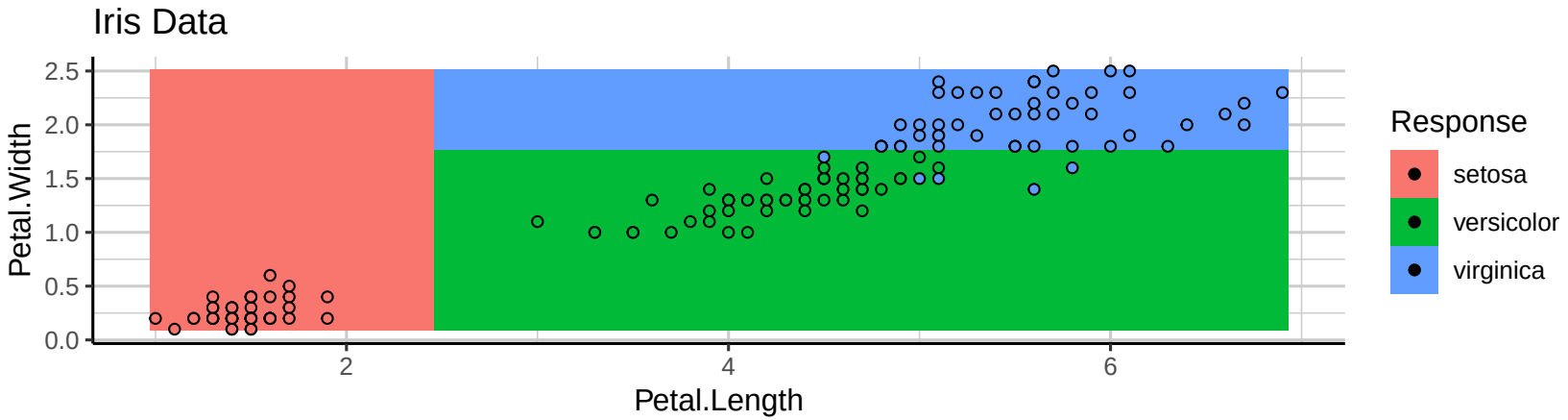
Start with a root node of all data, then search for a feature and split point that minimizes the empirical risk in the child nodes.

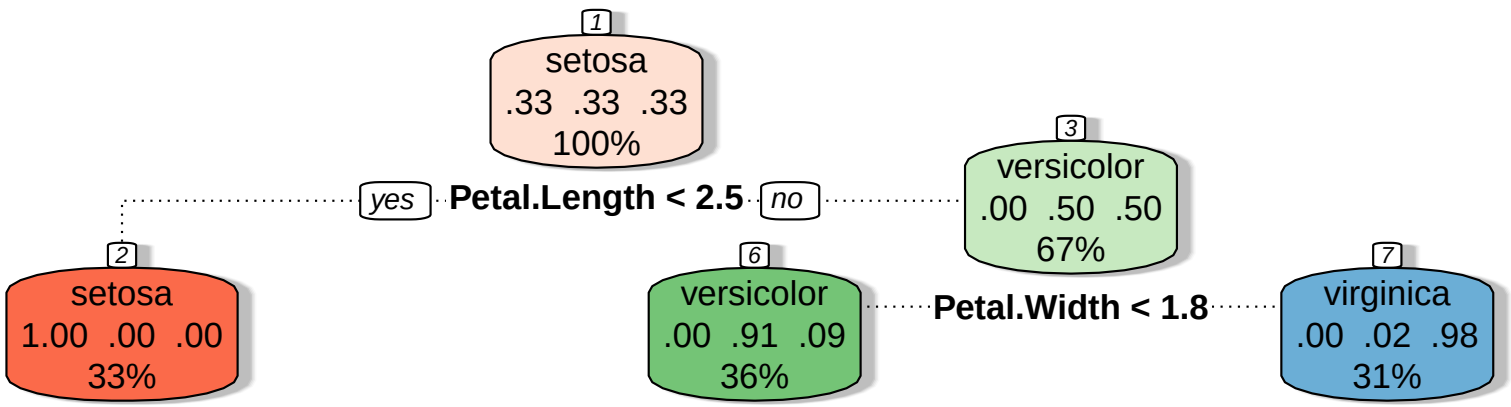


Nodes display their current label distribution here for illustration.

TREE GROWING

We then proceed recursively for each child node: Iterate over all features, and for each feature over all possible split points. Select the best split and divide data in parent node into left and right child nodes:





TREE GROWING

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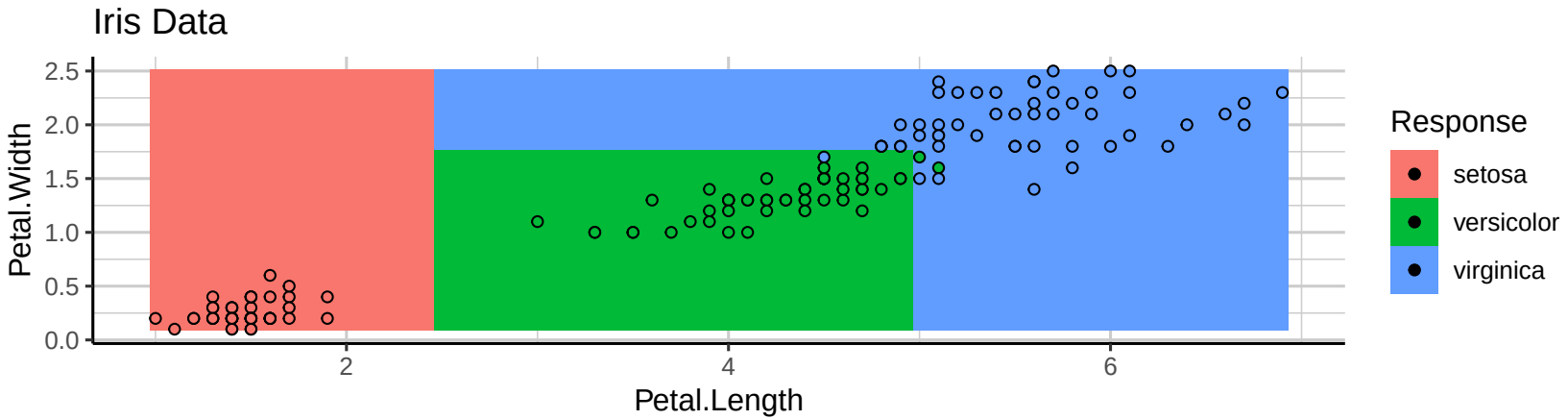
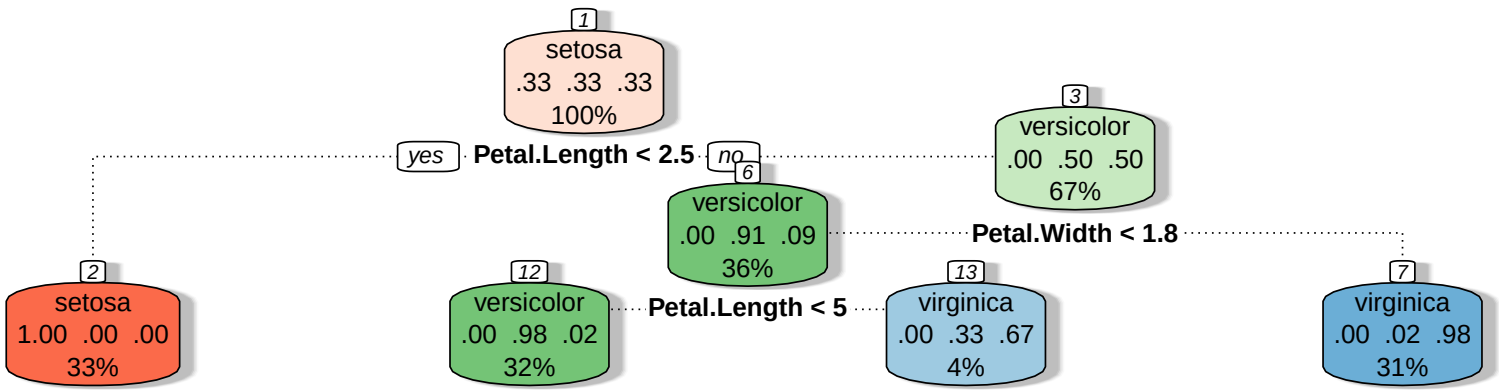
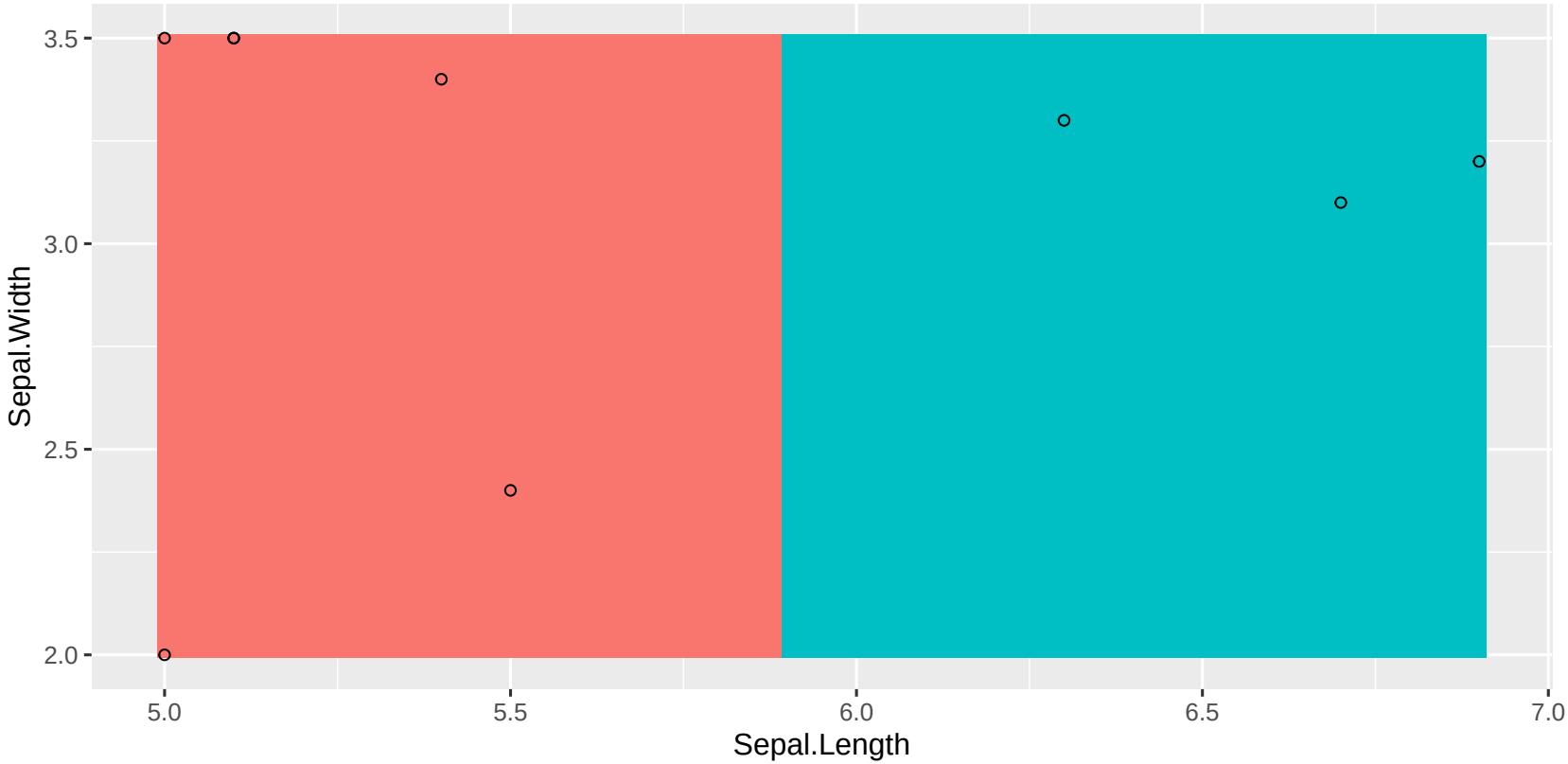




SPLIT PLACEMENT



Splits are usually placed at the mid-point of the observations they split: the large margin to the next closest observations makes better generalization on new, unseen data more likely.