# 极客大学算法训练营
# 第六课
# 树、二叉树、二叉搜索树


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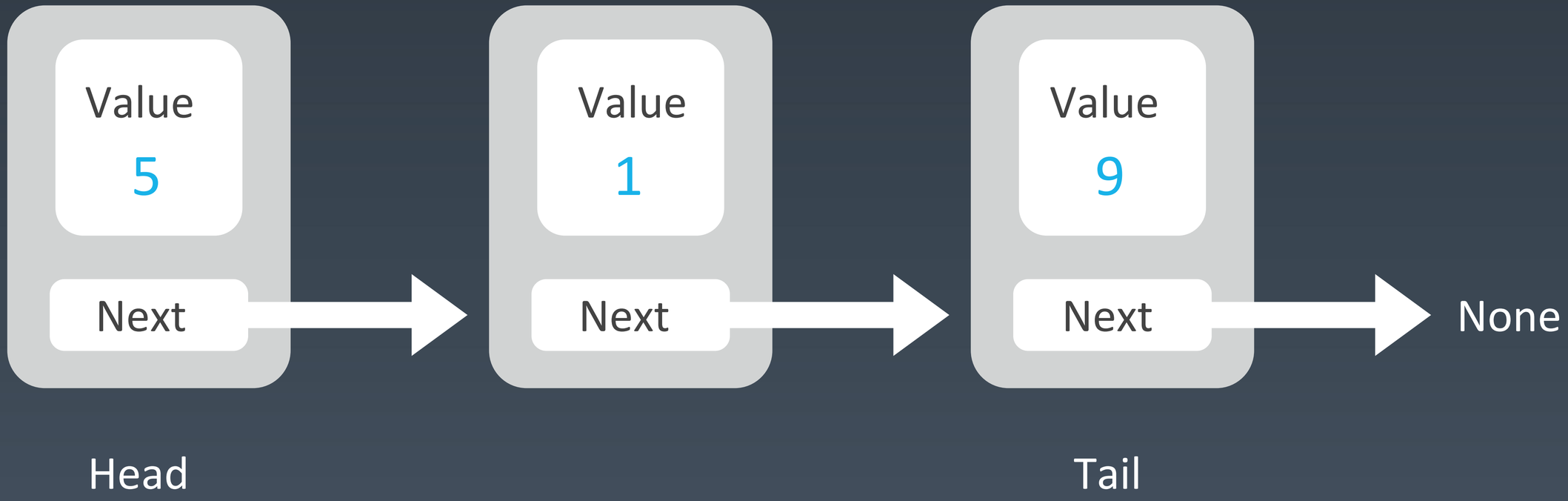
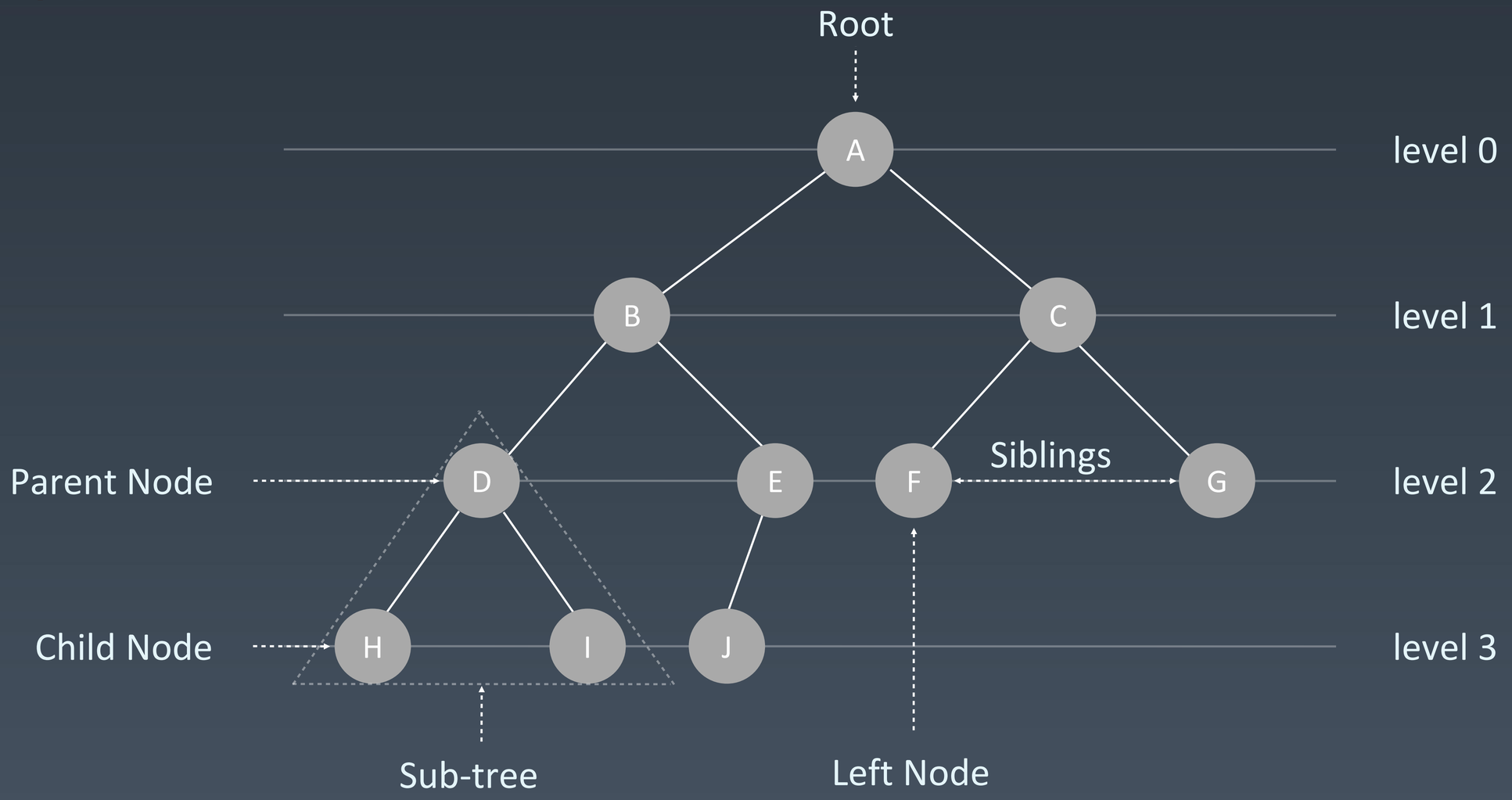
# 前序知识回顾：链表等一维结构

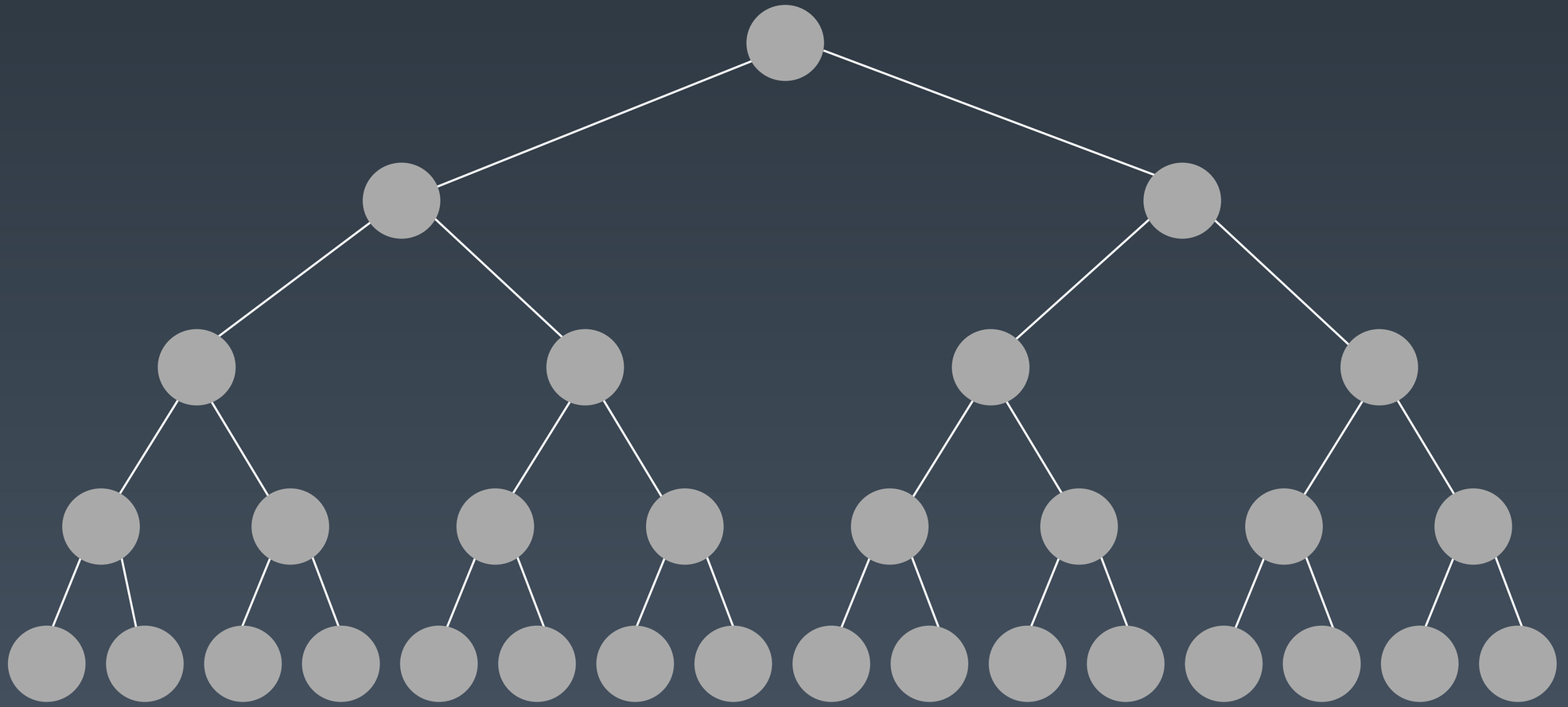
# 单链表 Linked List



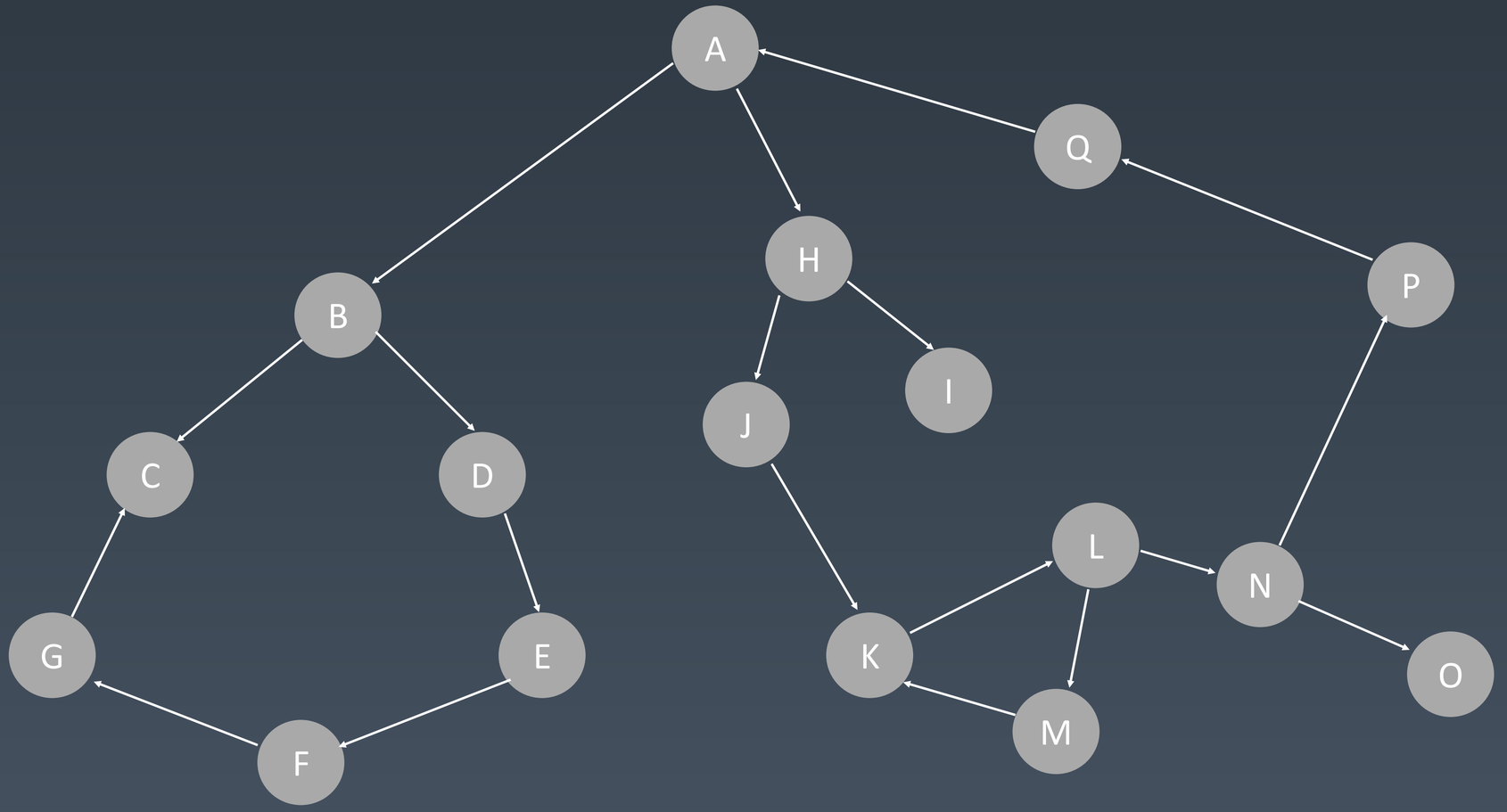
# 树 Tree


Root
A
level 0
B
C
level 1
Parent Node
D
E
F
Siblings
G
level 2
Child Node
H
I
J
level 3
Sub-tree
Left Node

# 二叉树 Binary Tree



# 图 Graph



Linked List 是特殊化的 Tree

Tree 是特殊化的 Graph

# 示例代码

Python

```python
class TreeNode:
    def __init__(self, val):
        self.val = val
        self.left, self.right = None, None
```

C++

```cpp
struct TreeNode {
    int val;
    TreeNode *left;
    TreeNode *right;
    TreeNode(int x) : val(x), left(NULL), right(NULL) {}
}
```

Java

```java
public class TreeNode {
    public int val;
    public TreeNode left, right;
    public TreeNode(int val) {
        this.val = val;
        this.left = null;
        this.right = null;
    }
}
```

# 二叉树遍历 Pre-order/In-order/Post-order

1.前序（Pre-order）：根-左-右

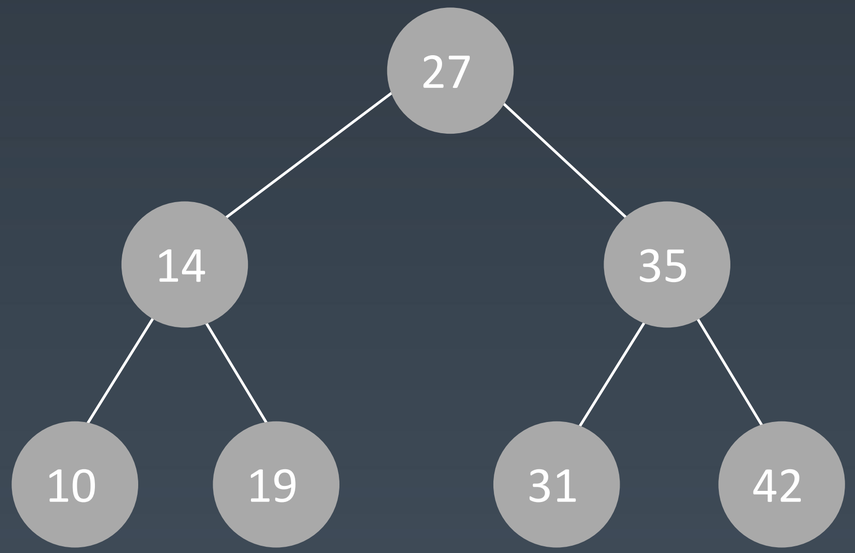
2.中序（In-order）：左-根-右

3.后序（Post-order）：左-右-根

# 示例代码

```
def preorder(self, root):

    if root:
        self.traverse_path.append(root.val)
        self.preorder(root.left)
        self.preorder(root.right)

def inorder(self, root):

    if root:
        self.inorder(root.left)
        self.traverse_path.append(root.val)
        self.inorder(root.right)

def postorder(self, root):

    if root:
        self.postorder(root.left)
        self.postorder(root.right)
        self.traverse_path.append(root.val)
```

# 二叉搜索树 Binary Search Tree



# 二叉搜索树 Binary Search Tree

二叉搜索树，也称二叉排序树、有序二叉树（Ordered Binary Tree）、排序二叉树（Sorted Binary Tree），是指一棵空树或者具有下列性质的二叉树：

1. 左子树上所有结点的值均小于它的根结点的值；
2. 右子树上所有结点的值均大于它的根结点的值；
3. 以此类推：左、右子树也分别为二叉查找树。（这就是 重复性！）

中序遍历：升序排列

# 二叉搜索树常见操作

1. 查询
2. 插入新结点（创建）
3. 删除

Demo: https://visualgo.net/zh/bst

# 复杂度分析

## Common Data Structure Operations

| Data Structure | Time Complexity | | | | | | | | Space Complexity |
|---|---|---|---|---|---|---|---|---|---|
| | Average | | | | Worst | | | | Worst |
| | Access | Search | Insertion | Deletion | Access | Search | Insertion | Deletion | |
| Array | Θ(1) | Θ(n) | Θ(n) | Θ(n) | O(1) | O(n) | O(n) | O(n) | O(n) |
| Stack | Θ(n) | Θ(n) | Θ(1) | Θ(1) | O(n) | O(n) | O(1) | O(1) | O(n) |
| Queue | Θ(n) | Θ(n) | Θ(1) | Θ(1) | O(n) | O(n) | O(1) | O(1) | O(n) |
| Singly-Linked List | Θ(n) | Θ(n) | Θ(1) | Θ(1) | O(n) | O(n) | O(1) | O(1) | O(n) |
| Doubly-Linked List | Θ(n) | Θ(n) | Θ(1) | Θ(1) | O(n) | O(n) | O(1) | O(1) | O(n) |
| Skip List | Θ(log(n)) | Θ(log(n)) | Θ(log(n)) | Θ(log(n)) | O(n) | O(n) | O(n) | O(n) | O(n log(n)) |
| Hash Table | N/A | Θ(1) | Θ(1) | Θ(1) | N/A | O(n) | O(n) | O(n) | O(n) |
| Binary Search Tree | Θ(log(n)) | Θ(log(n)) | Θ(log(n)) | Θ(log(n)) | O(n) | O(n) | O(n) | O(n) | O(n) |
| Cartesian Tree | N/A | Θ(log(n)) | Θ(log(n)) | Θ(log(n)) | N/A | O(n) | O(n) | O(n) | O(n) |
| B-Tree | Θ(log(n)) | Θ(log(n)) | Θ(log(n)) | Θ(log(n)) | O(log(n)) | O(log(n)) | O(log(n)) | O(log(n)) | O(n) |
| Red-Black Tree | Θ(log(n)) | Θ(log(n)) | Θ(log(n)) | Θ(log(n)) | O(log(n)) | O(log(n)) | O(log(n)) | O(log(n)) | O(n) |
| Splay Tree | N/A | Θ(log(n)) | Θ(log(n)) | Θ(log(n)) | N/A | O(log(n)) | O(log(n)) | O(log(n)) | O(n) |
| AVL Tree | Θ(log(n)) | Θ(log(n)) | Θ(log(n)) | Θ(log(n)) | O(log(n)) | O(log(n)) | O(log(n)) | O(log(n)) | O(n) |
| KD Tree | Θ(log(n)) | Θ(log(n)) | Θ(log(n)) | Θ(log(n)) | O(n) | O(n) | O(n) | O(n) | O(n) |

图片来源：http://www.bigocheatsheet.com/

# 树的面试题解法一般都是递归

# 为什么?

# 示例代码

Python

```python
class TreeNode:
    def __init__(self, val):
        self.val = val
        self.left, self.right = None, None
```

C++

```cpp
struct TreeNode {
    int val;
    TreeNode *left;
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    TreeNode(int x) : val(x), left(NULL), right(NULL) {}
}
```

Java

```java
public class TreeNode {
    public int val;
    public TreeNode left, right;
    public TreeNode(int val) {
        this.val = val;
        this.left = null;
        this.right = null;
    }
}
```

# 示例代码

```
def preorder(self, root):
    if root:
        self.traverse_path.append(root.val)
        self.preorder(root.left)
        self.preorder(root.right)


def inorder(self, root):
    if root:
        self.inorder(root.left)
        self.traverse_path.append(root.val)
        self.inorder(root.right)


def postorder(self, root):
    if root:
        self.postorder(root.left)
        self.postorder(root.right)
        self.traverse_path.append(root.val)
```

# 树的遍历 DEMO

# 实战题目

1. https://leetcode-cn.com/problems/binary-tree-inorder-traversal/
2. https://leetcode-cn.com/problems/binary-tree-preorder-traversal/
3. https://leetcode-cn.com/problems/n-ary-tree-postorder-traversal/
4. https://leetcode-cn.com/problems/n-ary-tree-preorder-traversal/
5. https://leetcode-cn.com/problems/n-ary-tree-level-order-traversal/

# THANKS!