Zhu et al., 2022). This leaf color change has a significant impact on the landscape effect. By rationally combining plants of different colors, the visual effect of the landscape can be enhanced (Wang, 2021; Mu et al., 2022).

With the continuous advancement of research techniques, people's understanding of the genetic mechanism of the color change of maple leaves has become more profound. Through genomic research, scientists have discovered some important genes related to anthocyanin synthesis, such as chalcone synthase and UFGT. At the same time, some transcription factors that can affect pigment accumulation and seasonal changes have also been found, such as MYB and bHLH (Sun et al., 2024). In the study of *Acer truncatum*, it was found that the phenomenon of gene duplication and the different expression levels of UFGT are closely related to the formation of red and yellow leaf varieties (Zhang et al., 2023). In the study of *Acer palmatum*, some gene combinations, such as ApWRKY26/ApERF4-ApMYB2, also participate in the synthesis process of anthocyanins in different seasons and play a regulatory role in the color change of leaves (Zhu et al., 2022; Chen et al., 2025). These studies indicate that the formation of the color of maple leaves is not only controlled by genetic factors but also influenced by environmental conditions. In the future, if the related physiological activities and gene expression can be regulated, there is hope to cultivate new ornamental varieties with more stable leaf colors or more obvious seasonal color changes (Zhao et al., 2020; Fan et al., 2024).

This study focused on analyzing the genetic basis of the color change of maple leaves and explored its application value in variety breeding and landscape design. By studying the relevant key genes and molecular markers, it is hoped to cultivate new varieties with brighter leaf colors, longer ornamental periods, and stronger adaptability. At the same time, the research on seasonal plant color combinations can also provide certain references for urban green space landscape design. Currently, the research results in leaf color genetics and the color configuration and spatial layout in landscape design still lack effective integration. This study attempts to link the leaf color formation mechanism with variety selection and seasonal configuration, providing ideas for ornamental plant breeding and further enhancing the visual, ecological and cultural value of maple tree landscapes.

2 Leaf Color Formation Mechanism

2.1 Functions of chlorophyll, carotenoids and anthocyanins

The color of maple leaves is mainly determined by three types of pigments, including chlorophyll a and b, carotenoids, and anthocyanins. Chlorophyll a and b are very important pigments for photosynthesis in plants. They mainly absorb blue light and red light, so in the season when plants are growing normally, the leaves are generally green (Lu et al., 2020). Carotenoids mainly include lutein and carotene. These pigments mainly absorb blue-violet light and their colors are usually yellow to orange. At the same time, they can also help the leaves reduce damage caused by strong light (Xie et al., 2023; Tian et al., 2024). Anthocyanins are water-soluble pigments present in the cell sap. Depending on their structure and the internal environment of the cells, they can manifest as red, purple or blue, and are particularly prominent in many colorful maple leaves (Chen et al., 2019; Jie et al., 2019; Gong et al., 2025).

These three types of pigments jointly determine the color of leaves and also participate in many normal life activities within the plant. Taking red maple as an example, chlorophyll is mainly related to photosynthesis, while carotenoids and anthocyanins are important substances that affect the color of leaves, and they can also help the plant adapt to external conditions such as strong light and temperature changes (Jie et al., 2019; Yang et al., 2022; Zhang et al., 2022; Gong et al., 2025). Studies have found that the formation process of these pigments is controlled by many genes, and the changes in the content of the three pigments, namely their increase or decrease, are the main reasons for the leaves to gradually change from green to yellow or red (Chen et al., 2019; Lu et al., 2020; Fan et al., 2024).

2.2 Diversity of maple leaf colors and pigment proportions

The colors of maple leaves vary mainly depending on the content and proportion of chlorophyll, carotenoids and anthocyanins. Taking a mutant red maple as an example, its leaves are divided into three types: green (GL), red (RL), and yellow (YL). Detection shows that the chlorophyll content is the highest in GL, medium in RL, and the lowest in YL; carotenoids are the most abundant in GL, and less and similar in RL and YL. The anthocyanin