Discuss the pros and cons of call-by-value and call-by-name semantics.

Consider the syntax of the following pure functional language

\[
\begin{align*}
e & ::= \ n \mid \text{fn } x : T \Rightarrow e \mid e \ e \mid x \mid \Omega \\
T & ::= \ \text{int} \mid T \rightarrow T
\end{align*}
\]

where the static and dynamic semantics of \( \Omega \) are given by rules

\[
\begin{align*}
(\text{omega}) & \quad \Gamma \vdash \Omega : \text{int} \\
(\text{omega}) & \quad \Omega \longrightarrow \Omega
\end{align*}
\]

Give typing rules and CBN dynamic semantic rules for the other constructs.

Give an expression that would behave differently in the CBV and CBN semantics, and give its final state in each (if any).

For this language, the desired type preservation result would be of the form “If \( \Gamma \vdash e : T \) and \( e \longrightarrow e' \) then \( \Gamma \vdash e' : T' \).” In proving that, a substitution lemma would be required. Give a statement and proof of that substitution lemma.