The classic model of transformational grammar, as developed in Chomsky (1955) and summarized in Chomsky (1957)

Phrase structure rules (context free re-writing rules) create an initial phrase marker.

(1) \[
\text{Sentence} \rightarrow \text{NP} + \text{VP} \\
\text{VP} \rightarrow \text{Verb} + \text{NP} \\
\text{NP} \rightarrow \left\{ \text{NP}_{\text{sing}} \right\} \\
\text{NP}_{\text{sing}} \rightarrow T + N + \emptyset \\
\text{NP}_{\text{pl}} \rightarrow T + N + S \\
T \rightarrow \text{the} \\
N \rightarrow \text{man, ball, etc.} \\
\text{Verb} \rightarrow \text{Aux} + V \\
V \rightarrow \text{hit, take, walk, read, etc.} \\
\text{Aux} \rightarrow \text{C(M)} (\text{have + en}) (\text{be + ing}) \\
M \rightarrow \text{will, can, may, shall, must}
\]

(2)

Transformations then sequentially alter the phrase marker. Two of them introduce a tense/agreement morpheme under C, and then attach this morpheme to the V (or to M or have or be).

(3) \[
\begin{align*}
\text{Number Transformation - obligatory} \\
\text{Structural analysis: } X - C - Y \\
\text{Structural change: } C \rightarrow \emptyset \text{ in other contexts} \\
\end{align*}
\]

(4) \[
\begin{align*}
\text{Auxiliary Transformation - obligatory} \\
\text{Structural analysis: } X - Af - v - Y \text{ (where Af is any C or is en or ing; v is any st or } V, \text{ or have or be) (29ii)} \\
\text{Structural change: } X_1 - X_2 - X_3 - X_4 \rightarrow X_1 - X_2 - X_3^{-} - X_4
\end{align*}
\]

<Called by all since the mid-1960s ‘Affix Hopping’>
The two transformations illustrated so far are designated ‘obligatory’ in the grammar, based on the empirical observation that failure to apply them results in unacceptable sentences. Other transformations are ‘optional’; an acceptable sentence (ultimately) results whether they are applied or not. The following is of the latter variety:

(7) \[
T_{\text{nat}} - \text{optional}:
\]

Structural analysis:
\[
\begin{align*}
\{NP - C & - V \ldots \} \\
\{NP - C + M & - \ldots \} \\
\{NP - C + have & - \ldots \} \\
\{NP - C + be & - \ldots \}
\end{align*}
\]

Structural change: \(X_1 - X_2 - X_3 \rightarrow X_1 - X_2 + n't - X_3\)

If we don’t apply this in a derivation beginning with (2), we ultimately generate:

(8) John left.

Suppose we do apply it to a structure similar to the one in (5), just with a different choice of V in the phrase structure component, and a different choice of C in the Number Transformation (3). ((7) is specified as ordered after the Number Transformation. Rule ordering is an interesting topic for another occasion.)) The immediate input and output are:
Now (4) can’t apply, since $s$ and $V$ are no longer adjacent. Under these circumstances, a pair of rules (which together came to be known as ‘do-support’) take over, yielding (11):
Conceptually, do-support is quite simple: Insert a dummy verb *do* to support a verbal affix that is otherwise unsupported. The technical implementation turns out to be quite tricky. See Lasnik (2000) for extensive discussion.

So starting with the initial phrase marker underlying (9) [just like (9), but without the *s* having been inserted yet], if we apply only obligatory transformations we get (13), what Chomsky termed a ‘kernel sentence’.

(13) John swims.

A variety of optional transformations were available, producing, among other things, all from the same initial phrase marker:

(14) John doesn’t swim.
(15) Does John swim?
(16) Doesn’t John swim?
(17) John does swim.

References

