sentences
The most common production rule for sentences is, 
$$S \rightarrow NP \ VP \ (8.27)$$
which accounts for simple sentences like Abigail ate the kimchi as we will see, the direct object the kimchi is part of the verb phrase. But there are more complex forms of sentences as well:
$$S \rightarrow ADVP \ NP \ VP \ (8.28)$$
$$S \rightarrow S \ CC \ S \ Abigail \ ate \ the \ kimchi \ and \ Max \ had \ a \ burger. \ (8.29)$$
$$S \rightarrow VP \ Eat \ the \ kimchi. \ (8.30)$$
where ADVP is an adverbial phrase (e.g., unfortunately, very unfortunately) and CC is a coordinating conjunction (e.g., and, but).7

nouns phrases
Noun phrases refer to entities, real or imaginary, physical or abstract. Asha, the steamed dumpling, parts and labor, nobody and the rise of revolutionary syndicalism in the early twentieth century. Noun phrases also include "bare" nouns, which may optionally follow determiners, as well as pronouns:
$$NP \rightarrow N\ N N S | N N P | PRP \ (8.31)$$
$$NP \rightarrow DET \ N N S | DET \ NNS | DET \ NNP \ (8.32)$$
The part-of-speech tags NN, NNS, and NNP refer to singular, plural, and proper nouns; PRP refers to personal pronouns, and DET refers to determiners. The grammar also contains terminal productions from each of these tags, e.g., PRP \rightarrow \{ | you | we \ | she | her \ | his \ | her \}.

Noun phrases may be modified by adjectival phrases (ADJP), e.g., the small Russian dog and numbers (CD; e.g., the five pastries, each of which may optionally follow a determiner:
$$NP \rightarrow ADJP \ NN | ADJP \ NNS | DET \ ADJP \ NN | DET \ ADJP \ NNS \ (8.33)$$
$$NP \rightarrow CD \ NNS | DET \ CD \ NNS | \ldots \ (8.34)$$

Notice that the grammar does not include the recursive production S \rightarrow ADVP S. It may be helpful to think about why this production would cause the grammar to overgenerate:

Some noun phrases include multiple nouns, such as the liberation movement and an antelope horn, necessitating additional productions:
$$NP \rightarrow NN \ NN \ | NN \ NNS | DET \ NN \ NN | \ldots \ (8.35)$$
These multiple noun constructions can be combined with adjectival phrases and cardinal numbers, leading to a large number of additional productions.

Recursiv noun phrase productions include coordination, prepositional phrase attachment, subordinate clauses, and verb phrase adjuncts:
$$NP \rightarrow NP \ CC \ NP | e.g., \the \ red \ and \ the \ black \ (8.36)$$
$$NP \rightarrow NP \ PP | e.g., \the \ President \ of \ the \ Georgian \ Institute \ of \ Technology \ (8.37)$$
$$NP \rightarrow NP \ SBR | e.g., \the \ bicycle \ that \ I \ found \ outside \ (8.38)$$
$$NP \rightarrow NP \ VP | e.g., \a \ bread \ made \ of \ titanium \ (8.39)$$

These recursive productions are a major source of ambiguity, because the VP and NP non-terminals can also generate NP children. Thus, the the President of the Georgian Institute of Technology can be derived in two ways, as an NP consisting of the President of the Institute, or as a NP consisting of the Georgian Institute of Technology, followed by an NP consisting of the President.

verbs phrases
Verb phrases describe actions, events, and states of being. The PTB tagset distinguishes several classes of verb inflections: base form (VB; she likes to snack), present-tense third-person singular (VZ; she snacks), present tense but not third-person singular (VBP; they snack), past tense (VBD; they snacked), past participle (VBG; they are snacking), and past participle (VBN; they had snacked). Each of these forms can constitute a verb phrase on its own:
$$VP \rightarrow VB | VEZ | VBD | VBN | VBG | VBP \ (8.40)$$

More complex verb phrases can be formed by a number of recursive productions, including the use of coordination, modal verbs (Mo; should snack), and the infinitival to (To):

Each of these productions uses recursion, with VP appearing on the right-hand side. This enables the creation of very complex verb phrases, such as she will have wanted to have been snacking.

Transitive verbs take noun phrases as direct objects, and ditransitive verbs take two direct objects:
$$VP \rightarrow VZ \ S | Asha \ wants \ to \ eat \ the \ kimchi \ (8.50)$$
$$VP \rightarrow VZ \ S \ BNR Asha \ knows \ that \ they \ eat \ the \ kimchi \ (8.51)$$
The first production overgenerates, licensing sentences like *Asha sees Boyang eats the kimchi. This problem could be addressed by designing a more specific set of sentence non-terminals, indicating whether the main verb can be conjugated.

Verbs can also be modified by prepositional phrases and adverbial phrases:
$$VP \rightarrow VZ \ PP | She \ studies \ at \ night \ (8.52)$$
$$VP \rightarrow VZ \ ADVP | She \ studies \ intensively \ (8.53)$$
$$VP \rightarrow ADVP \ VBG | She \ is \ not \ studying \ (8.54)$$

Again, because these productions are not recursive, the grammar must include productions for every verb part-of-speech.

A special set of verbs, known as copula, can take predicative adjectives as direct objects:
$$VP \rightarrow VZ \ ADJP | She \ is \ hungry \ (8.55)$$
$$VP \rightarrow VBP \ ADJP | Success \ seems \ increasingly \ unlikely \ (8.56)$$
The PTB does not have a special non-terminal for copular verbs, so this production generates non-grammatical examples such as *She eats tall.

Particles (PR; as a particle; Ri; as a part-of-speech) work to create phrasal verbs:
$$VP \rightarrow Vz \ PR T | They \ gave \ up \ their \ ill-gotten \ gains \ (8.57)$$
$$VP \rightarrow Vz \ PRT \ NP | They \ gave \ up \ their \ ill-gotten \ gains \ (8.58)$$

As the second production shows, particle productions are required for all configurations of verb parts-of-speech and direct objects.

other constituents
The remaining constituents require far fewer productions. Prepositional phrases almost always consist of a preposition and a noun phrase, 
$$PP \rightarrow IN \ NP \ United \ States \ of \ America \ (8.59)$$
$$PP \rightarrow TO \ NP \ He \ gave \ his \ kimchi \ to \ Abigail \ (8.60)$$

Similarly, complement clauses consist of a complementizer (usually a preposition, possibly null) and a sentence,
$$SBR \rightarrow IN \ S \ She \ said \ that \ it \ was \ spicy \ (8.61)$$
$$SBR \rightarrow S \ She \ said \ that \ it \ was \ spicy \ (8.62)$$

Adverbial phrases are usually bare adverbs (ADVP \rightarrow RB), with a few exceptions:
$$ADVP \rightarrow \ RB \ RBR \ They \ went \ considerably \ further \ (8.63)$$
$$ADVP \rightarrow ADVP \ PP \ They \ went \ considerably \ further \ than \ before \ (8.64)$$
The tag RBR is a comparative adverb.

Adjectival phrases extend beyond bare adjectives (ADJP \rightarrow JJ) in a number of ways:
$$ADJP \rightarrow JJ \ very \ hungry \ (8.65)$$
$$ADJP \rightarrow JR \ JJ \ more \ hungry \ (8.66)$$
$$ADJP \rightarrow JJ \ best \ possible \ (8.67)$$
$$ADJP \rightarrow JR \ JJ \ even \ bigger \ (8.68)$$
$$ADJP \rightarrow JJ \ CC \ JJ \ high \ and \ mighty \ (8.69)$$
$$ADJP \rightarrow JJ \ West \ German \ (8.70)$$
$$ADJP \rightarrow RBN \ previously \ reported \ (8.71)$$
The tags JR and JJ refer to comparative and superlative adjectives respectively.

All of these phrase types can be coordinated:
$$PP \rightarrow PP \ CC \ PP \ on \ time \ and \ under \ budget \ (8.72)$$
$$ADVP \rightarrow ADVP \ CC \ ADVP \ now \ and \ two \ years \ ago \ (8.73)$$
$$ADJP \rightarrow ADJP \ CC \ ADJP \ quaint \ and \ rather \ deceptive \ (8.74)$$
$$SBR \rightarrow SBR \ CC \ SBR \ whether \ they \ want \ control \ or \ whether \ they \ want \ exports \ (8.75)$$

using this grammar, and reasonable POS tags, please:
1. Draw parse trees for these phrases: 
   -redeye flights [this is not an S] 
   - I need to fly between Philadelphia and Atlanta.
2. Invent a new sentence that has a syntactic ambiguity. Draw it and two legitimate parse trees for it.