Translation Options

- Look up possible phrase translations
  - many different ways to segment words into phrases
  - many different ways to translate each phrase

Hypothesis Expansion

- Start with empty hypothesis
  - e: no English words
  - f: no foreign words covered
  - p: probability 1

- Pick translation option
- Create hypothesis
  - e: add English phrase Mary
  - f: first foreign word covered
  - p: probability 0.534

- Further hypothesis expansion

Explosion of Search Space

- Number of hypotheses is exponential with respect to sentence length
  - Decoding is NP-complete [Knight, 1999]
  - Need to reduce search space
    - risk free: hypothesis recombination
    - risky: histogram/threshold pruning
Hypothesis Recombination

- Different paths to the same partial translation

Recombined hypotheses do not have to match completely
No matter what is added, weaker path can be dropped, if:
- last two English words match (matters for language model)
- foreign word coverage vectors match (effects future path)

Pruning

- Hypothesis recombination is not sufficient
  ⇒ Heuristically discard weak hypotheses
- Organize Hypothesis in stacks, e.g. by
  - same foreign words covered
  - same number of foreign words covered (Pharaoh does this)
  - same number of English words produced
- Compare hypotheses in stacks, discard bad ones
  - histogram pruning: keep top \( n \) hypotheses in each stack (e.g. \( n=100 \))
  - threshold pruning: keep hypotheses that are at most \( \gamma \) times the cost of best hypothesis in stack (e.g. \( \gamma = 0.001 \))