

Chapter 13: Heat Shock Response

To adjust to abrupt increases in temperature, bacteria induce the expression of more than 30 different genes

Heat shock genes are also induced by types of stress that affect proteins

Examples of heat shock proteins:

- **Chaperones:** fold newly synthesized proteins, help re-fold denatured proteins, and target proteins for degradation
- **Proteases:** destroy denatured proteins before they poison the cell
 - Lon, ClpP, ClpX

Transcription of Heat Shock Genes

Heat shock genes have promoters for both σ^{70} and the alternative sigma factor: σ^{32}

➤ Constitutively expressed, but induction of heat shock genes only occurs after increase in temperature

- Normal levels of σ^{32} are low in the cell, but increase ~15 fold after increase in temperature

DnaK: “Cellular thermometer”

➤ Keeps level of σ^{32} low under normal conditions

- DnaK bound to σ^{32} also inhibits activity of the sigma factor

DnaK, σ^{32} binding, and heat shock

- Transcription of *dnaK* increases during heat shock because promoter is recognized by σ^{32}
- However, increased temperature yields denatured proteins which are also a target for DnaK
- Free σ^{32} builds up in the cell → binds to promoters for heat shock genes and induces transcription
- Once enough DnaK has accumulated to bind to all unfolded proteins and cellular conditions have adjusted to the increase in temperature, free DnaK can bind and inhibit σ^{32}

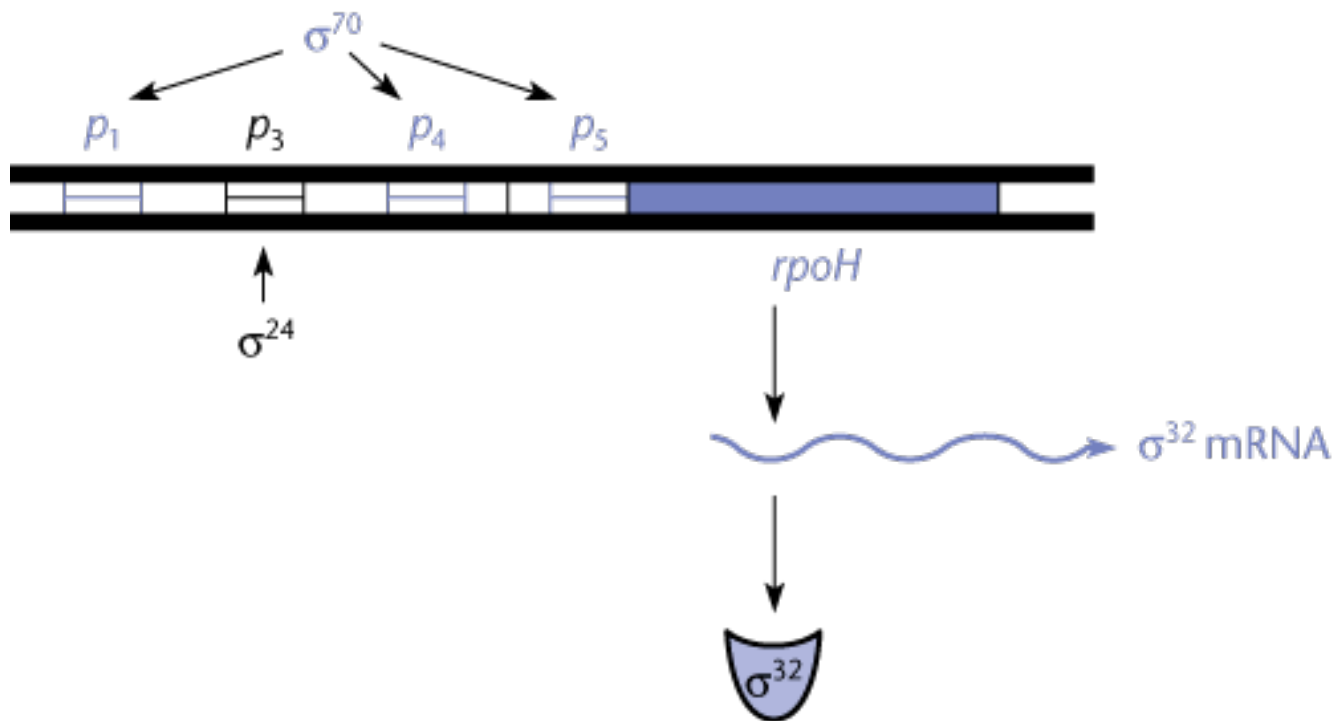
Transcriptional and Translation Control of σ^{32}

Transcriptional Control

- *rpoH* gene contains 3 promoters for σ^{70}

➤ Constitutive expression

- *rpoH* gene contains 1 promoter for σ^{24}



Alternative sigma factor: σ^{24}

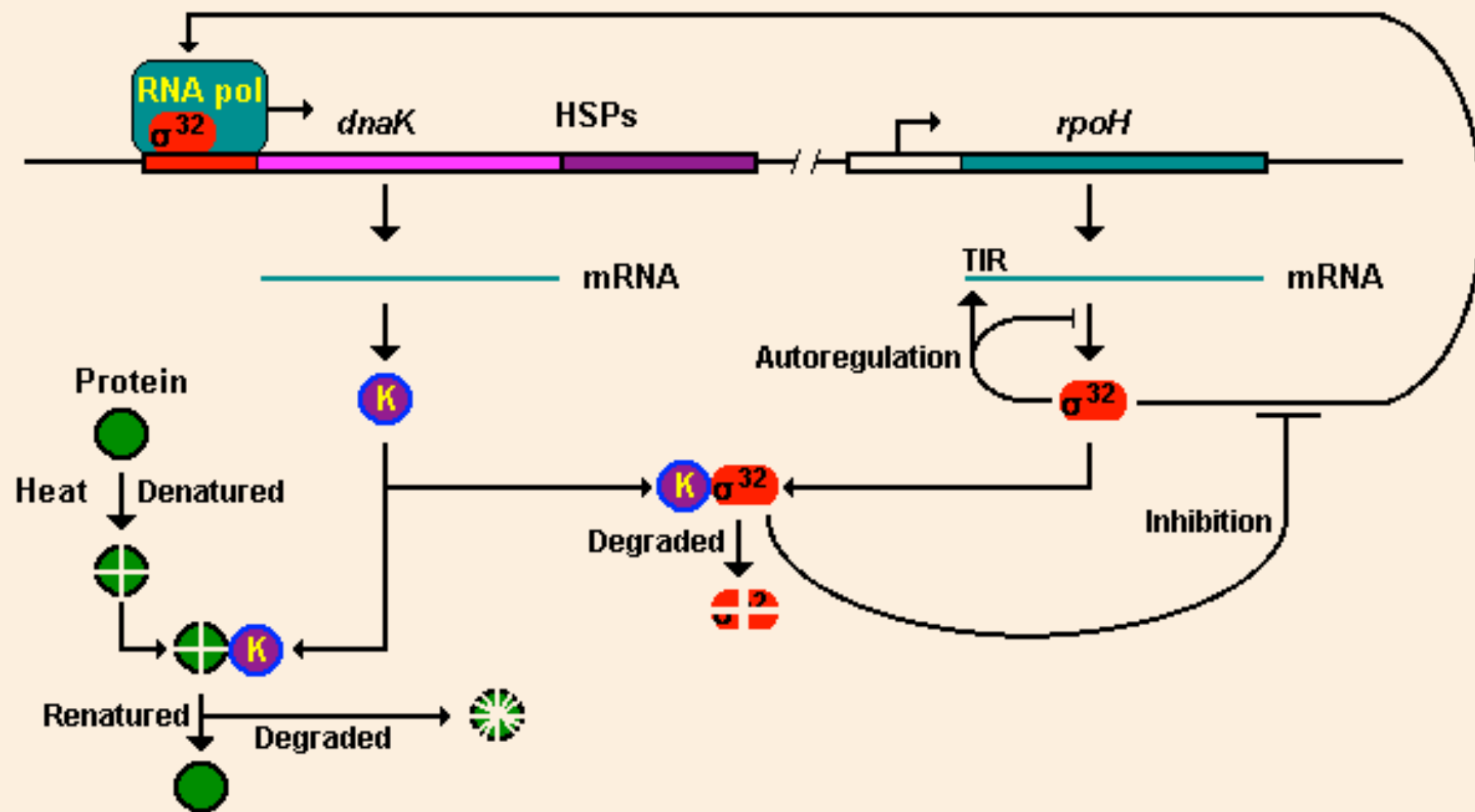
- Encoded by the *rpoE* gene
- Recognizes promoters for genes that respond to extra-cytoplasmic stress
- Under normal cellular conditions, the RseA protein binds to σ^{24} inhibits activity of the sigma factor
- If the membrane is stressed: a protease degrades RseA, allowing σ^{24} to bind to its specific promoters
 - heat shock causes proteins in membrane to unfold thus σ^{24} will be free to recognize P3 for *rpoH*

Translational Control

- σ^{32} binds to its own translation initiation region under high concentrations
 - decreased translation of *rpoH* transcript due to blocking of ribosome

- Secondary structures occur in *rpoH* transcript
 - Under higher temperature, secondary structures are unfolded

Heat Shock response



Overview of Regulatory Mechanism in the Heat Shock Response