Min protein oscillations in *Escherichia coli*

1. Overall picture

Escherichia coli (or *E. Coli*; see Fig.1) is a kind of bacteria that are prokaryotic cells. They are one of the best-studied prokaryotic models [see reference 1], the studied results from *E.coli* often being extended or adapted to knowledge relating to other bacteria.

In *E. coli*, cell division is an essential process, and the selection of the division site is regulated in part by three Min proteins: MinC, MinD, and MinE. It is first reported in 1989 that they prevent it from minicell division [2]

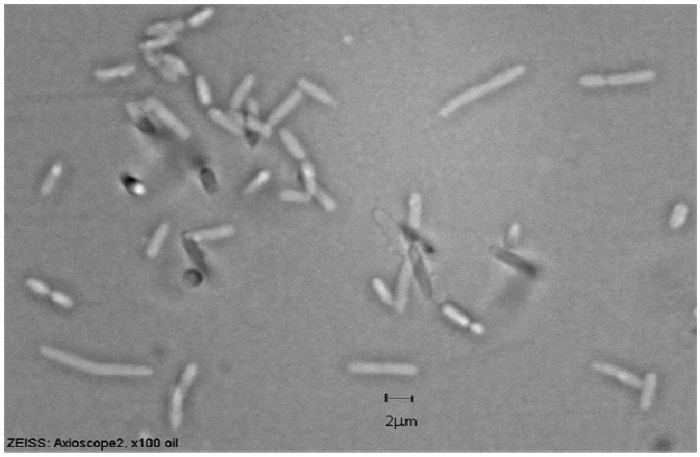

Figure 1 An example of rod shape *E.coli* cells.

2. Min proteins oscillations

In order to describe their functions to the cell division site properly, Min protein dynamics have been proposed via models of Min protein oscillations. The simplest one is the model of Huang et al (2003) [3]. In this model, the reported *in vitro* Min proteins are accounted and described in deterministic reaction-diffusion equations. Oscillation is described as beginning with MinD in the cytoplasm binding to the membrane when there is ATP present—and where the binding MinD prefers to bind next to the preceding bound MinD, resulting in a compact polar zone of MinD. The MinD-ATP complex is activated by MinE to release MinD-ADP, phosphate, and MinE itself into the cytoplasm, resulting in the two highest intensity ring forms called the E-ring around the middle cell. The MinD-ADP is converted back to MinD-ATP in the cytoplasm, and diffuses to the other pole where the process is repeated, resulting in the repeated characteristic of Min protein dynamics called Min protein oscillations. The schematic diagram for these oscillations is illustrated by Fig. 2

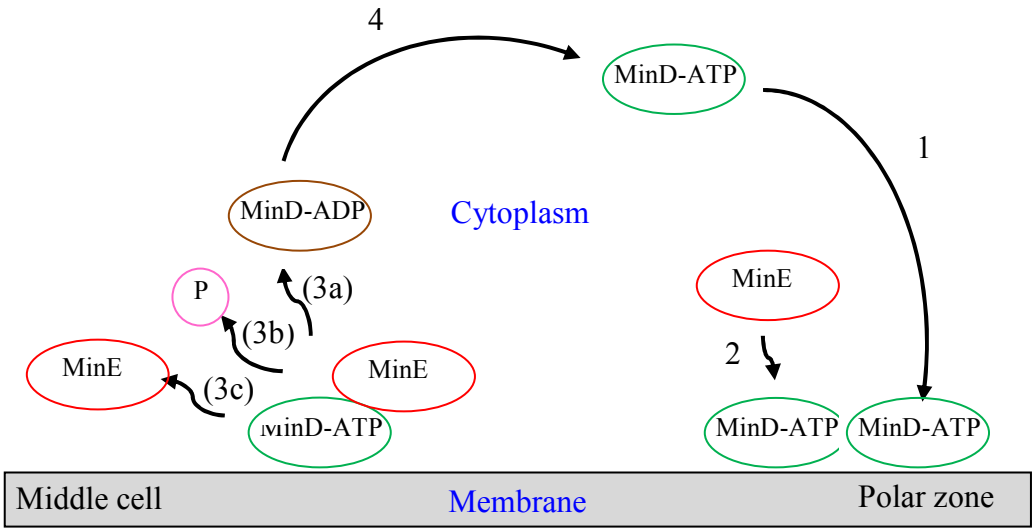

Figure 2 Model of MinD, MinE cycle driven by ATP hydrolysis. In this model MinC is thought to be co-localized with MinD. In the first step, the cytoplasmic MinD-ATP complex attaches to the membrane, preferentially where other MinD-ATP is bound. **2**: MinE in the cytoplasm attaches to a membrane-associated MinD-ATP complex and releases MinD-ADP (3a), phosphate (3b), and MinE (3c) into the cytoplasm. **4**: MinD-ADP is converted back into MinD-ATP by the nucleotide exchange process.

3. The latest research

The research investigate the effect of temperature on the dynamics of MinE protein oscillation by monitoring pattern formation and measuring the dynamics of MinE protein clusters, including positions, speed, and (more importantly) periods, using a spot tracking technique (STT).The experimental results of the periods from 12 individual cells is shown in the Fig. 3. The oscillation period of MinE protein decreases when temperature is increased. Specifically, the MinE oscillation period decreases about threefold as the temperatures changed from 23.3 to 42.0^{o}C, which is consistent with studies on the growth rate of *E. coli*. The study characterized the detailed dependence between the period and temperature as an exponential decay. It is proposed that this dependence might relate to the Arrhenius equation, with an estimated activation energy of 10 kcal/ mol. The results could establish a knowledge-base for the relationship between the cell division process and the temperature-dependent rates within a prokaryotic cell.

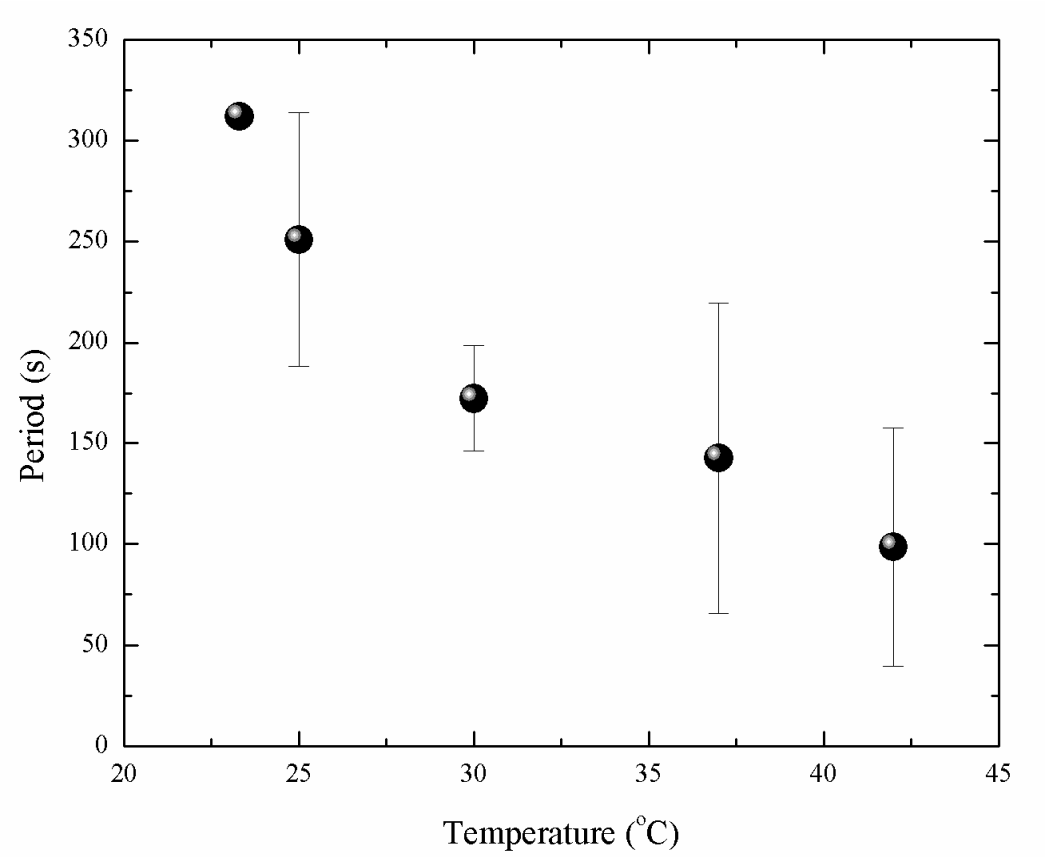

Figure 3 The MinE oscillation periods in seconds observed at 23.3, 25.0, 30.0, 37.0, and 42.0^{o}C, respectively. The standard errors are represented by the vertical bars.

REFERENCES

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2. De Boer, P., A., J., Crossley, R., E., & Rothfield, L., I. (1989). A division inhibitor and a topological specificity factor coded for by the minicell locus determine proper placement of the division septum in *E. coli*. *Cell.* 56 (4), 641-649.
3. Huang, K., C., Meir, Y., & Wingreen, N., S. (2003). Dynamic structures in *Escherichia coli*: Spontaneous formation of MinE rings and MinD polar zones. *PNAS.* 100 (22), 12724–12728.