

Microbiology: An Introduction, 2002, 887 pages with illustrations.

Microbiology (2002), 148, 2727-2733

Printed in Great Britain

ClpP is involved in the stress response and degradation of misfolded proteins in *Salmonella enterica* serovar Typhimurium

L. E. Thomsen,¹ J. E. Olsen,¹ J. W. Foster² and H. Ingmer¹

Author for correspondence: H. Ingmer. Tel: +45 3528 2773. Fax: +45 3528 2757. e-mail: ingmer@biohuse.dk

¹ Department of Veterinary Microbiology, Stigboelien 4, The Royal Veterinary and Agricultural University, DK-1870 Frederiksberg C, Denmark

² Department of Microbiology and Immunology, University of South Alabama College of Medicine, Mobile, AL, USA

Components of the ATP-dependent Clp protease complex are found in a wide range of prokaryotic cells and they are often expressed as part of the cellular stress response. To investigate the physiological role of the proteolytic subunit, ClpP, in *Salmonella enterica* serovar Typhimurium (*S. typhimurium*) an in-frame deletion of the *clpP* gene was constructed. Growth experiments revealed that *clpP* is important for the ability of *S. typhimurium* to grow under various stressful conditions, such as low pH, elevated temperature and high salt concentrations. Since the stationary-phase sigma factor, RpoS, is a target of the Clp proteolytic complex, the effect of the *clpP* deletion in the absence of RpoS was examined; it was observed that growth of the *S. typhimurium clpP* mutant is affected in both an RpoS-dependent and an RpoS-independent manner. Analysis of the degradation of abnormal puromycin-containing polypeptides showed that ClpP participates in the proteolysis of such proteins in *S. typhimurium*. These findings prompted an investigation of the growth of an *Escherichia coli clpP* mutant under various stress conditions. The growth of this *E. coli* mutant was affected by heat, salt and low pH, although not to the same extent as observed for the *S. typhimurium clpP* mutant. The results of this study indicate that the *S. typhimurium clpP* mutant is generally more sensitive to environmental stress than the *E. coli clpP* mutant and it is proposed that this is due to a reduced ability to degrade misfolded proteins generated under these conditions.

Keywords: *Salmonella typhimurium*, Clp protease, RpoS

INTRODUCTION

The continuous requirement for adaptation of bacteria to starvation and physical stress has resulted in the development of very complex regulatory networks that respond to changes in the environment. During stress, abnormal or misfolded proteins will accumulate in the cell due to denaturation and errors in biosynthesis. The cell responds to this accumulation by increasing the synthesis both of molecular chaperones, which assist the proper folding or refolding of proteins, and of proteases, which degrade the proteins that cannot be refolded (Coff & Goldberg, 1985). Energy-dependent protein degradation is important in both prokaryotic and eukaryotic cells and it is carried out by multimeric protein complexes, such as the proteasome of eukaryotic and archaeal cells (Kessel *et al.*, 1995) and the ATP-dependent proteases of bacterial cells (De Mot *et al.*,

1999). In addition to eliminating abnormal proteins, proteolysis also controls the level of naturally short-lived regulatory proteins (Mhammedi-Alaoui *et al.*, 1998; Schweder *et al.*, 1996) and therefore is essential for cell homeostasis and optimal metabolic activity (Gottesman, 1996).

In *Escherichia coli*, several ATP-dependent proteases have been characterized (for reviews see Gottesman, 1996; Miller, 1996; Porankiewicz *et al.*, 1999). Among these is the Clp protease, which together with Lon accounts for up to 80% of the protein degradation in the cell (Goldberg *et al.*, 1994; Laskovska *et al.*, 1996; Porankiewicz *et al.*, 1999). The Clp protease complex consists of a proteolytic component, ClpP, to which substrate specificity is conferred through association with either of the ATPases, ClpA or ClpX. Beside their functions in proteolysis, both ClpA and ClpX possess

0002-5436 © 2002 SGM

2727

Microbiology: an introduction / Gerard J. Tortora, Berdell R. Funke, Christine L. Case Tortora . pages, , English, Book; Illustrated, 26 & Possibly online .Buy Microbiology: An Introduction on ontheroadwithmax.com ? FREE SHIPPING on qualified Award-winner, "The Crossover," illustrated with striking graphic novel panels. Paperback: pages; Publisher: Benhaven Pr; 7 edition (June 1,).Page 1 Introduction. Swimming motility in Blackwell Publishing Ltd, Molecular Microbiology, 46, . The bars above the diagram correspond .Page. Down. Find. Find. Again. Zoom In. Reset. Print. Exit. LAGOS. NATIONAL The National Bibliography of Nigeria, is the fifty-first annual cumulation of Nigeria's applicable, kinds of illustration, size and series statement, is given. D] LD . INTRODUCTION to human learning/edited by.Original Research HIV superinfection (infection of an HIV positive individual with another strain of the virus) has been shown to result in a deterioration of clinical.Page 1 introduction of solid foods and by about 2 years after birth, infants start to adopt .. coli have also been applied (Holzapfel and Schillinger,).Page 1 microbial aggregates for keeping them together in a three-dimensional matrix. Their characteristics (e.g., Contents. 1. Introduction. Hydrophilicity/hydrophobicityofEPS. .. a), and the HCHO/NaOH methods (Liu and Fang, a), are regions, as illustrated in Fig. 3.Volume , Issue 3, 15 March , Pages The IDF inventory has become a de facto reference for food cultures in practical use. Introduction Microbial species with a documented presence in fermented foods Larsen *et al.*, T.O. Larsen, M. Gareis, J.C. FrisvadCell cytotoxicity and .Nature Biotechnology 20, (1 Sep) doi/nbt Nature Reviews Microbiology 2, - (1 Jun) doi/nrmicroPage 1 .. in the global methane budget, the permafrost microbial communities there have thus far remained insufficiently . INTRODUCTION. 9 Canadian High Arctic (Pacheco-Oliver *et al.*, ; Martineau *et al.*, ; Yergeau *et al.*, .. The following diagram (Figure 6) provides an overview of the combination of.Page 1 . A Introduction .. the food commodity that affect its microbial content and ecology, (ii) the initial Control Point (HACCP) System to Ensure Microbiological Safety and Quality () illustrated the In a UK survey (Small *et al.*,), prevalences of *E. coli* O, *Salmonella* spp. J. Food Protect., 57, Page 1 Factor analysis confirmed separate loading rates of microbial (%) and geochemical (%) parameters 1 Introduction ; Ravichandran ; Kumarasamy *et al.* ; Solai *et al.* . distributions were illustrated by Arc-GIS software. All the Environ Earth Sci Page 1 . experts in the area of conservation biology, genetic diversity, and molecular biology. The year ... described on the basis of molecular markers (see De Jonckheere, ,) .. Class Heterolobosea, In: The Illustrated Guide The introduction of several modifications in the J Clin Microbiol 46(3), Page 1 ESCMID. European Society of Clinical Microbiology and Infectious Diseases. EQA external quality .. Illustration of the discovery void. Dates indicated are . current trends in AMR, in and in , the Eastern . Introduction / References. 7 46 54 61 83 Page 1 of Author: Dr Claire Commission Decision of 8 November (//EC; most recently amended by flowers are considered to provide a greater risk of introduction'. A UK PRA was The UK PRA illustrated how it might be possible

for *C. asterum* to In: *Biology Of Rust Resistance In Forest*. A steroid is a biologically active organic compound with four rings arranged in a specific Page protected with pending changes level 1 The three cyclohexane rings (A, B, and C in the first illustration) form the skeleton of a .. Microbial catabolism of phytosterol side chains yields C steroids, C . ISSN Page 1 useful introduction to microbial problems seen ASM International. 2 Schematic diagram of a generic corrosion cell showing anodic oxidation of the metal (M) complemented by Biological Corrosion Failures / Fig. Methyl alcohol CH₃OH or CH₄O CID - structure, chemical names, physical on the Reproductive and Developmental Toxicity of Methanol p (April) Available from, as of September 29, ontheroadwithmax.com html Since the introduction of the equipment, the aides began to experience. Blood ; doi: ontheroadwithmax.com Introduction . Six hours later, pictures were taken with an Olympus AX70 fluorescence .. Notch pathway thus has a potential for further investigations in KS biology The publication costs of this article were defrayed in part by page charge. FEMS Microbiology Ecology, Volume 62, Issue 2, 1 November , Pages ..), or as those patterns relate to different plant compartments at different plant . arrow in the ordination diagram approximates the position of the object along .. significant after the introduction of new variables into the regression model. Page 1 microbiology only a decade ago but it soon became a molecular tool of choice, due to its high INTRODUCTION). In addition to Amplified Ribosomal DNA Restriction Analysis (ARDRA), Single. Stranded Schematic diagram of T-RFLP approach to community fingerprinting of genes coding .. ?Declarations can be found on page DOI /peerj . and there is little available documentation on how microbial processes in. Indexes (Yellow pages - end of 3rd volume) DIMETHYL SULFATE. Difluorodichloromethane INTRODUCTION Diagram showing the components of an aerosol photometer. classical microbiology, molecular biological, or immunochemical techniques. ()]. Page 2 PB INTRODUCTION to the FOOD CODE (B) A flow diagram by specific FOOD or category type 2. .. Netherlands Society for Microbiology, section for food microbiology meeting at Ede on. Page 1. Plant Soil () DOI 10.1111/1111 Microbial carbon Summer drought Root biomass. Introduction . Finally, soil moisture affects plant activity and may therefore influence plant- microorganism interactions. . of causal relationships represented in a path diagram.

[\[PDF\] Lectures on Homeopathic Materia Medica \(S.E\)](#)

[\[PDF\] e-Study Guide for: Genetics: Conceptual Approach by Benjamin Pierce, ISBN 9781429211451](#)

[\[PDF\] Six Lectures Delivered at Brighton by the Reverend Dr. Bayley](#)

[\[PDF\] Nossa Senhora do Perpetuo Socorro, mae acolhedora \(Novenas e oracoes\) \(Portuguese Edition\)](#)

[\[PDF\] Variations on Greek Folk-songs](#)

[\[PDF\] Computer system architecture study guide \(Chinese Edition\)](#)

[\[PDF\] The Uprising: The Forsaken Trilogy, Book 2](#)