

Not all that Glitters is Silver: Introduction to Microbial Silver Resistance

Dr. Matthias Noll

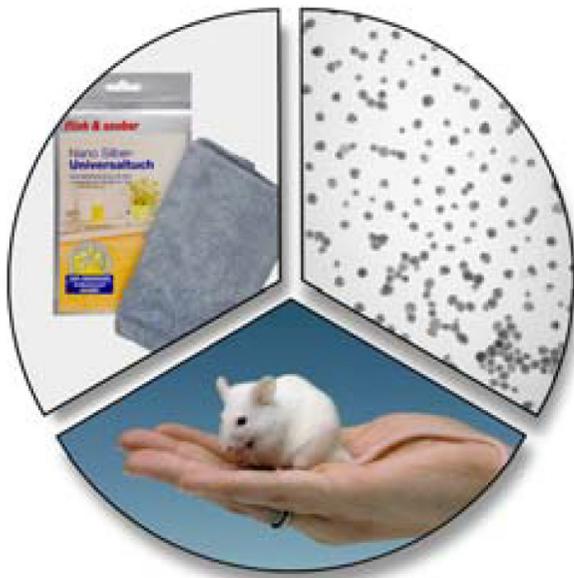
Hygiene and Microbiology

Risk Assessment for consumer protection

Consumers come into contact with products such as cosmetics, food packaging and toys on a daily basis

The task of BfR is to assess these products and contribute to product safety through recommendations

Product safety is hence an important task of consumer protection



Recommendation 024/2010 for the application of nano silver



BfR recommends that nano-silver is not used in foods and everyday products

BfR Opinion Nr. 024/2010, 28 December 2009

Manufacturers of foods, cosmetics or everyday products have long been taking advantage of the antimicrobial properties of silver ions. Lotions may contain silver salts as preservatives and refrigerators or athletic socks and other textiles are equipped with silver compounds in order to inhibit the growth of germs or avoid the development of odours. In recent times,

Minimal inhibition of silver

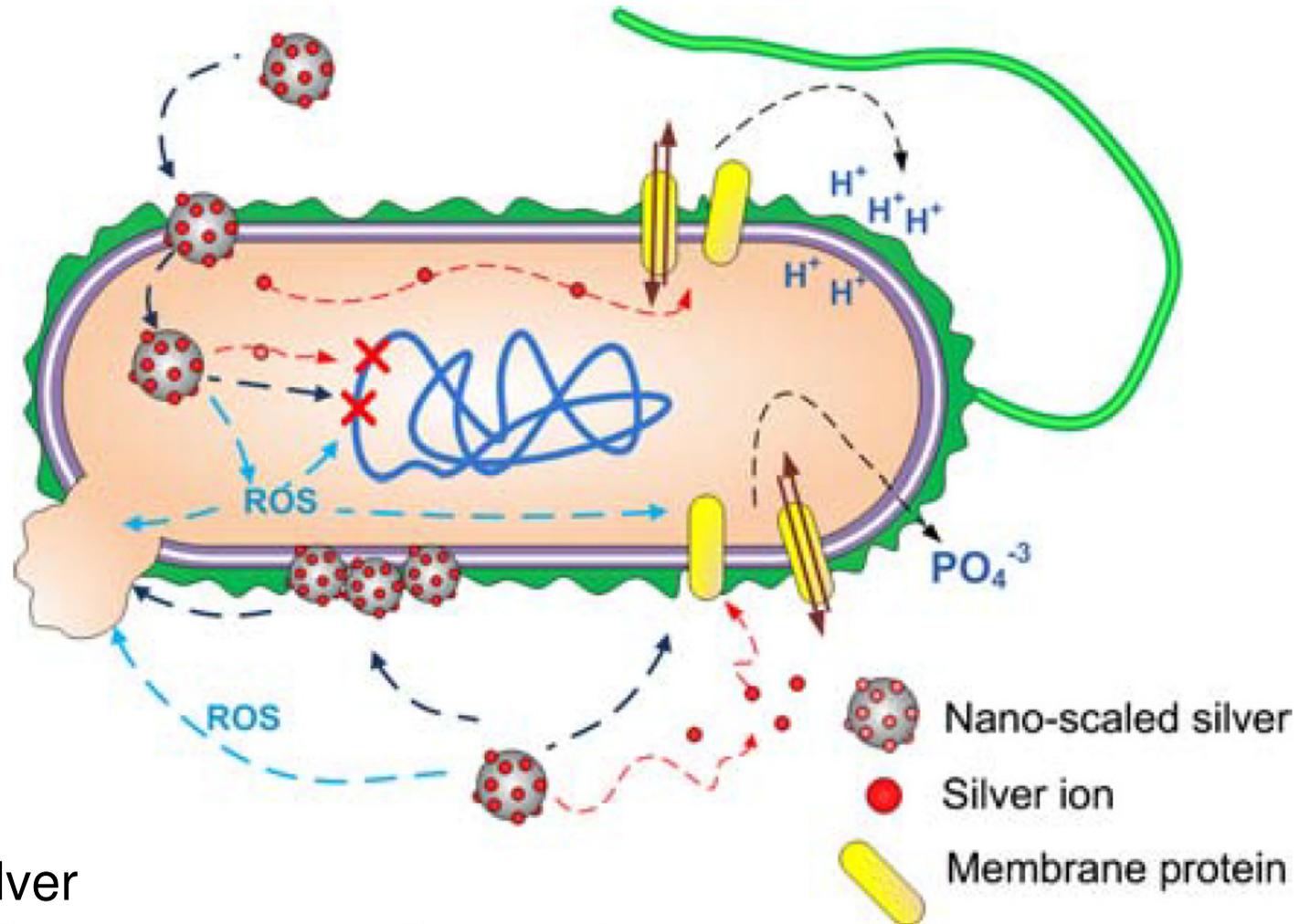
Products including silver compounds were designed as topical antimicrobial agent

Silver compounds have to be continuously bio-available to inhibit target microorganisms

Minimal inhibition concentration differed between tested microorganisms

Microorganisms	Minimal Inhibition Concentration (MIC)	Literature
<i>Staphylococcus aureus</i>	8 – 80 ppm AgNO ₃	Chopra, 2007
<i>Pseudomonas aeruginosa</i>	8 – 70 ppm AgNO ₃	Chopra, 2007
Bacterial gram-positive and gram-negative isolates	2,7 – > 5540 ppm AgNO ₃	Ip et al., 2006

Proposed mechanisms of silver in non-resistant microorganisms



- (1) Uptake of free silver
- (2) Disruption of ATP production and DNA replication
- (3) Generation of Reactive oxygen species (ROS)
- (4) Damage of cell membranes

Marambio-Jones and Hoek, 2010

Distribution of silver resistant microorganisms

Heavy metal contaminated sites (silver mines, landfills including photo industrial waste and others) (Haefeli et al., 1984)

Water catchment / Waste water environments (Griffitt et a., 2008, Bradford et al., 2009)

Food packages, water distribution systems, etc. (Silver et al., 2003)

Clinical environments such as human and animal wounds, catheters and medical devices (McHugh et al., 1975; Woods et al. 2009)

Frequently are silver contaminated environments correlated to microbial antibiotic resistance (McHugh et al., 1975; Wright et al., 2006; Baker-Austin et al., 2006)

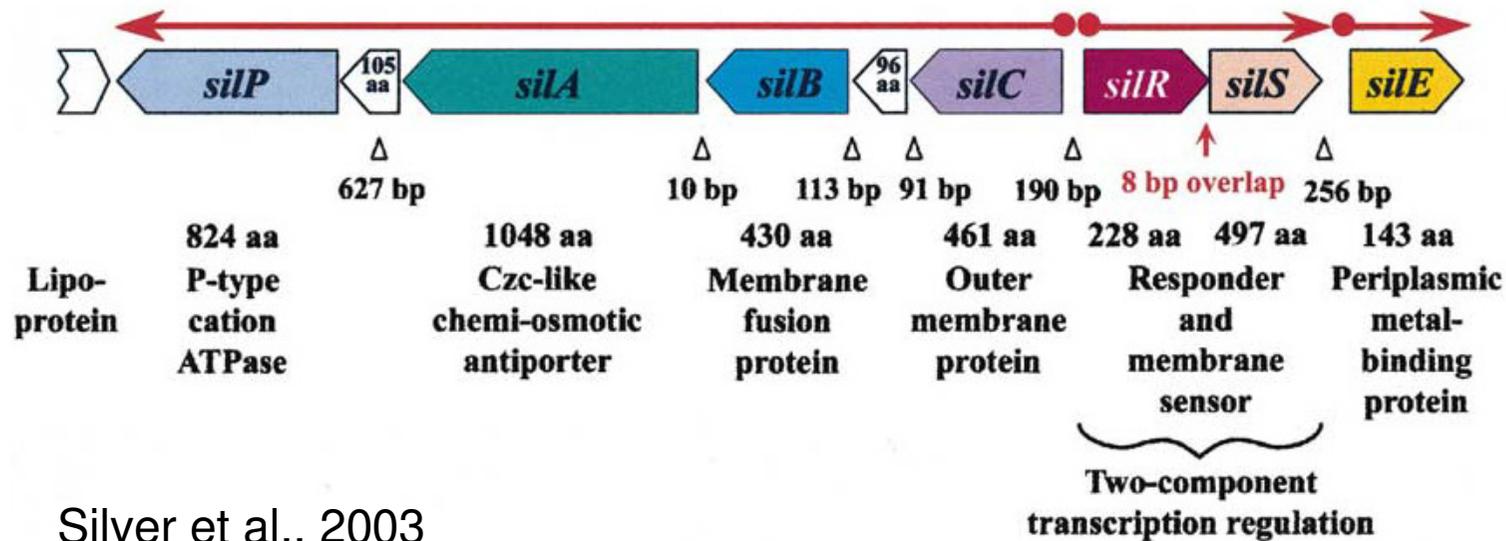
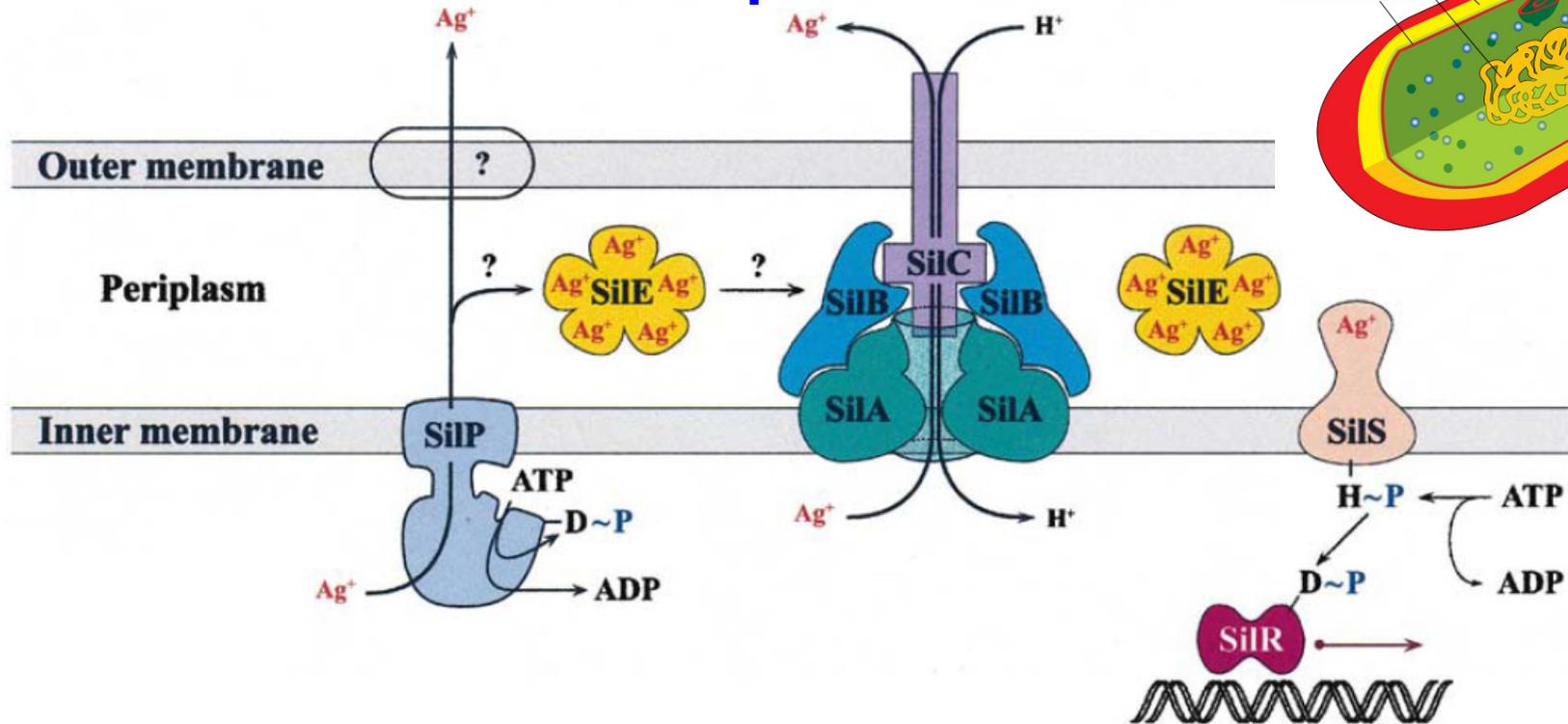
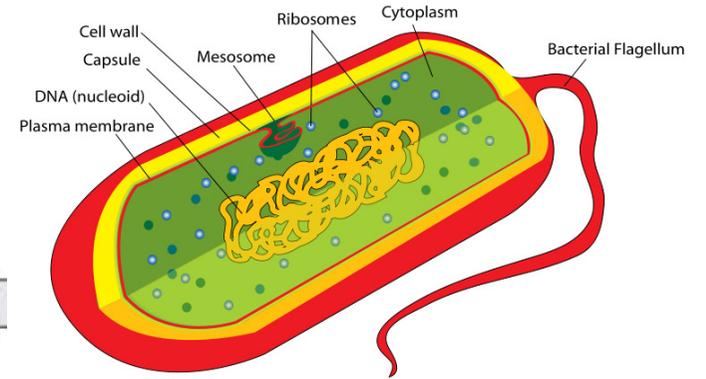
Microbial Silver Resistance

Pathogenic and non-pathogenic microorganisms that are silver resistant were isolated from both **clinical** (Carr and Rosenkranz, 1975; Annear et al., 1976; Hendry and Stewart, 1979; Markowitz et al., 1983; Slots et al., 1990; Klasen, 2000; Woods et al., 2009) and **environmental habitats** (Belly and Kydd, 1982; Haefeli et al., 1984; Grewal and Tiwari, 1990; Choudhury and Kumar, 1998)

Plasmid-borne silver resistance

<i>Salmonella typhimurium</i>	pMG101	(McHugh et al., 1975; Silver et al., 2003)
<i>Pseudomonas stutzeri</i>	pKK1	(Haefeli et al., 1984)
<i>Pseudomonas aeroguginosa</i>	not described	(Bridges et al., 1979)
<i>Acinetobacter baumannii</i>	pUPI199	(Deshpande and Chopade, 1994)
<i>Enterobacter cloacae</i>	not described	(Woods et al., 2009)

Genetic information on plasmids



Silver et al., 2003

Plasmid characteristics and plasmid transfer

Plasmids are encoding for manifold other resistances such as mercury, tellurite and several antibiotics (Gupta et al., 1998; 1999; 2001)

Transfer of plasmids via conjugation is possible, but has led to both silver resistant and non-resistant strains (Deshpande and Chopade, 1994)

Microbial silver resistance can be induced by stepwise exposure to silver (Li et al., 1997)

Summary

Genes encoding for microbial silver resistance are widespread in the bacterial tree of life

Genes for silver resistance are frequently linked to additional resistances

Systematic studies evaluating the abundance and functioning of silver resistance in clinical and environmental environments are rare

The use of nano silver is increasing in many fields of application leading to increased exposure

The effect in each application at sub-optimal conditions (e. g. sub-lethal concentrations) on target as well as on non-target microorganisms is so far not assessed

Goals for upcoming research





Risiken erkennen – Gesundheit schützen

Thank you for your attention

Dr. Matthias Noll

BfR, Federal Institute for Risk Assessment

Diedersdorfer Weg 1, D-12277 Berlin

Tel. +49 30 - 184 12 - 2182 Fax +49 30 - 184 12 - 2699

matthias.noll@bfr.bund.de

www.bfr.bund.de