



Non-thermal Plasma Infection Control



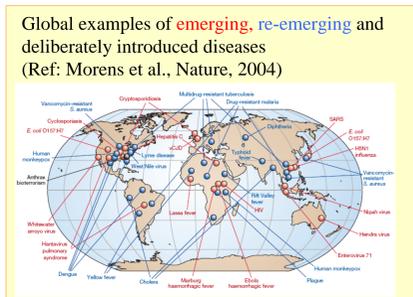
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Background

Global Factors Promoting Spread of Infectious Disease

- globalization: rapid movement of people, food, microbes
- explosive population growth, rise of large cities, coupled with poverty, urban migration and limited public health facilities
- intensive/concentrated livestock industry
- global climate change disrupting ecosystems
- antimicrobial resistance: inexorable rise in number of resistant microbes limits use of traditional infection control (e.g. antibiotics)
- emerging threat of bioterrorism

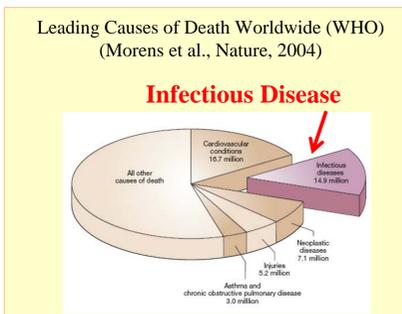
Global examples of **emerging, re-emerging** and deliberately introduced diseases (Ref: Morens et al., Nature, 2004)



Hospital-Acquired Infections ('Nosocomial' Infections)

- catheter-associated urinary tract infections
- catheter-related bloodstream infections
- surgical site infections
- ventilator-associated pneumonia
- prion and biomolecule infections

Complicating matters, antimicrobial resistance is developing for virtually all currently available drugs: **a post-antibiotic era may be coming!**



Plasma-assisted infection control

1. Plasma used to sterilize/disinfect environment

- air and/or aerosol-based microbes
- water-based microbes
- microbes on objects/surfaces ('fomites')

2. Plasma used to sterilize/disinfect in/on devices

- medical device surface (e.g. surgical)
- catheter extra-luminal or intra-luminal (e.g. vs. biofilm)
- implant device sterilization

3. Plasma on skin/wounds/burns or during invasive procedure

- hand hygiene; pre-/post-invasive procedure
- coupled with immune system/wound repair
- **key role of reactive oxygen/nitrogen species ROS/RNS**

Antimicrobial species generated from oxygen and nitrogen

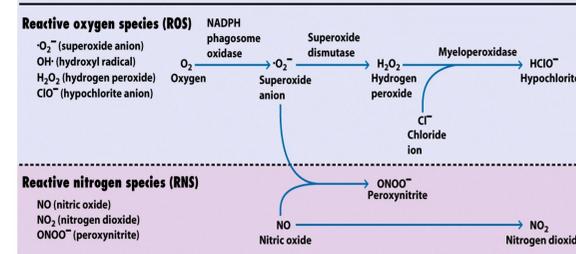
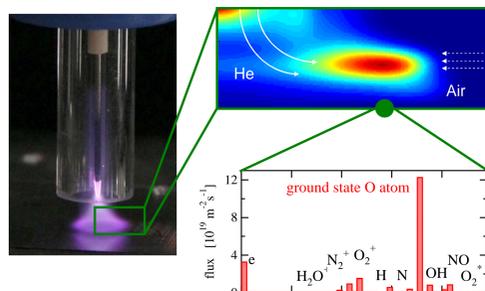
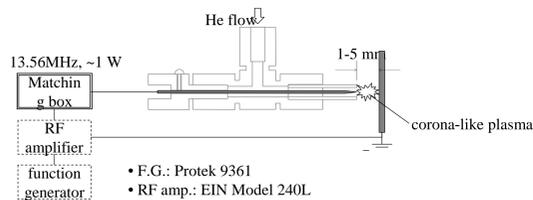


Figure 3-13
Kuby IMMUNOLOGY, Sixth Edition
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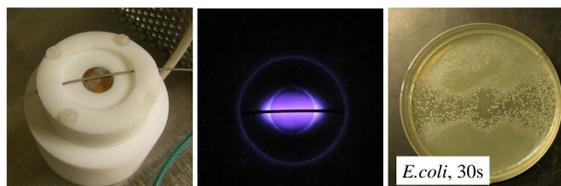
Possible non-thermal plasma devices for infection control

Helium plasma needle



Air DBD

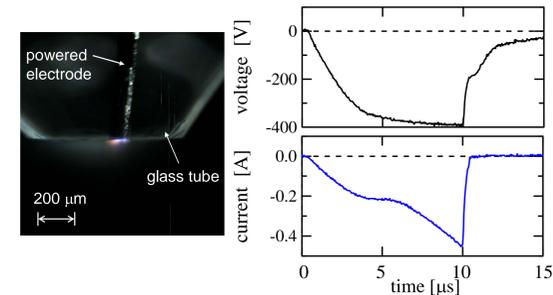
Indirect-mode



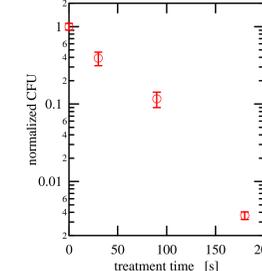
Direct-mode



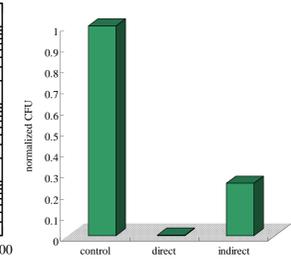
Microplasmas in solution



survival curve



plasma cocktail



Concluding remarks

- The challenge is huge. Antibiotic resistance and hospital-acquired infections, coupled with other infectious disease problems worldwide: **infection control is imperative!**
- ROS and RNS are central players in the body's defense against ID agents as well as playing other key biochemical roles.
- Atmospheric pressure, low temperature plasmas are **prolific, inexpensive, and simple generators of ROS and RNS.**
- The opportunity is clear for plasma-assisted infection control: chemistry that mimics the innate immune system can be used on/near body

References

- D. M. Morens et al., Nature, 430, (2004) 242.
- T. J. Kindt et al, *Kuby Immunology* 6th edition (W. H. Freeman, 2006).
- Y. Sakiyama et al, Plasma Sources Sci. Technol. 18 (2009) 025022.
- Y. Sakiyama et al, Appl. Phys. Lett. 94 (2009) 161501.