



Anti-Microbial Metal Oxides

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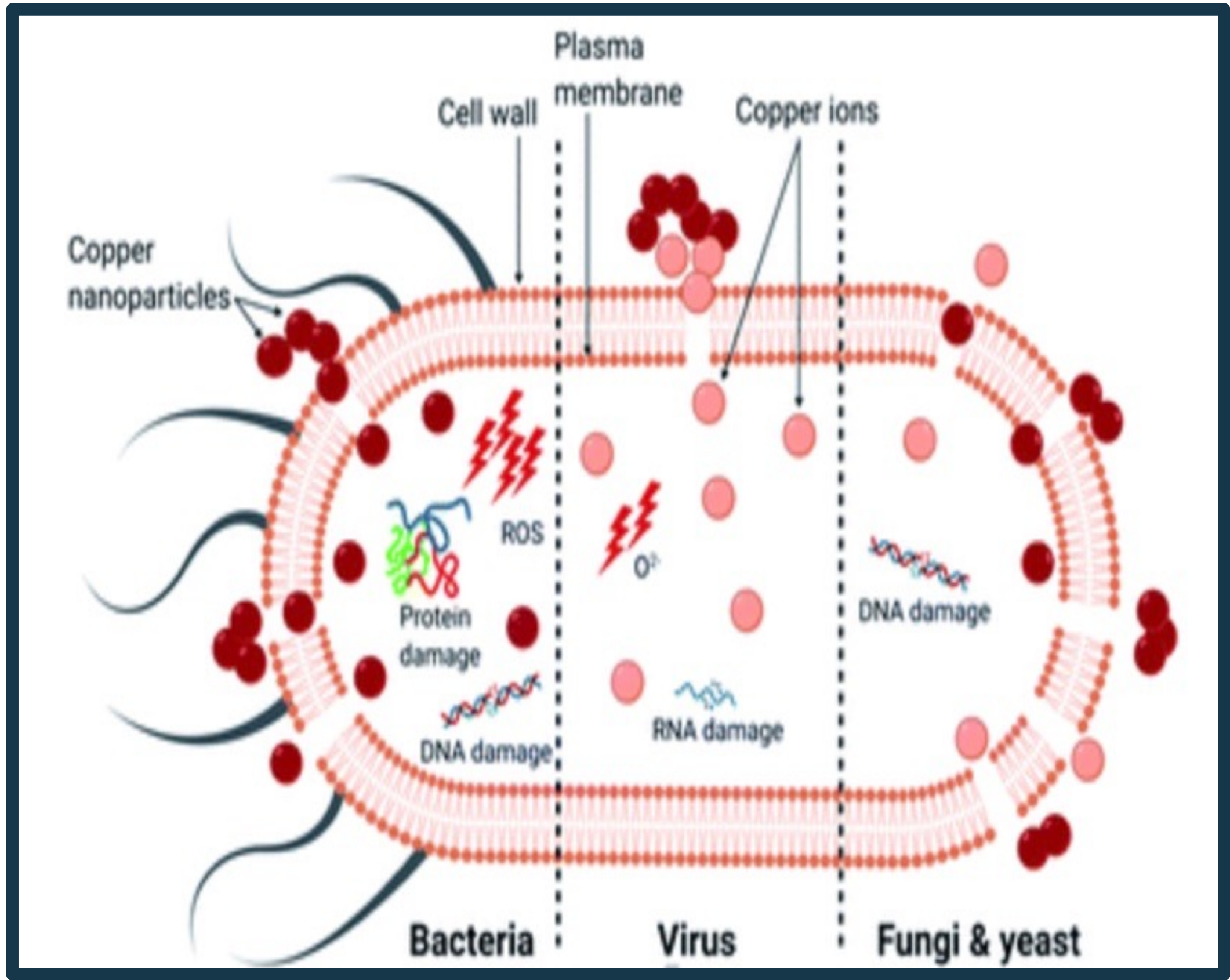
Abstract

This study examined the antimicrobial effects of metals of varying oxidation states against *E. coli*, focusing on metal ion diffusion. Copper exhibited the highest bacterial inhibition by releasing Cu^{2+} and Cu^+ ions, which disrupt membranes and cause oxidative damage. Copper content correlated directly with inhibition zone size, although brass was less effective than expected. This was potentially due to impregnated phosphorus limiting ion release and oxidation. Pre-oxidized metals significantly enhanced bacterial inhibition, with copper showing the greatest improvement. Bronze and stainless steel showed little to no antimicrobial effects. These findings support the use of copper-based alloys in healthcare, food safety, and public spaces to reduce bacterial contamination and improve hygiene in high-contact environments.

Material	Main Elements
110 Copper	99.9% Cu
510 Bronze	Cu 95, Sn 5
260 Brass	Cu 70, Zn 30
304 Stainless Steel	Fe 68-71, Cr 18-20, Ni 8-10.5
Silver Dollar	Ag (typically ~90%), Cu (~10%)
Gold Coin	Au (varies by purity, often 90-99%)

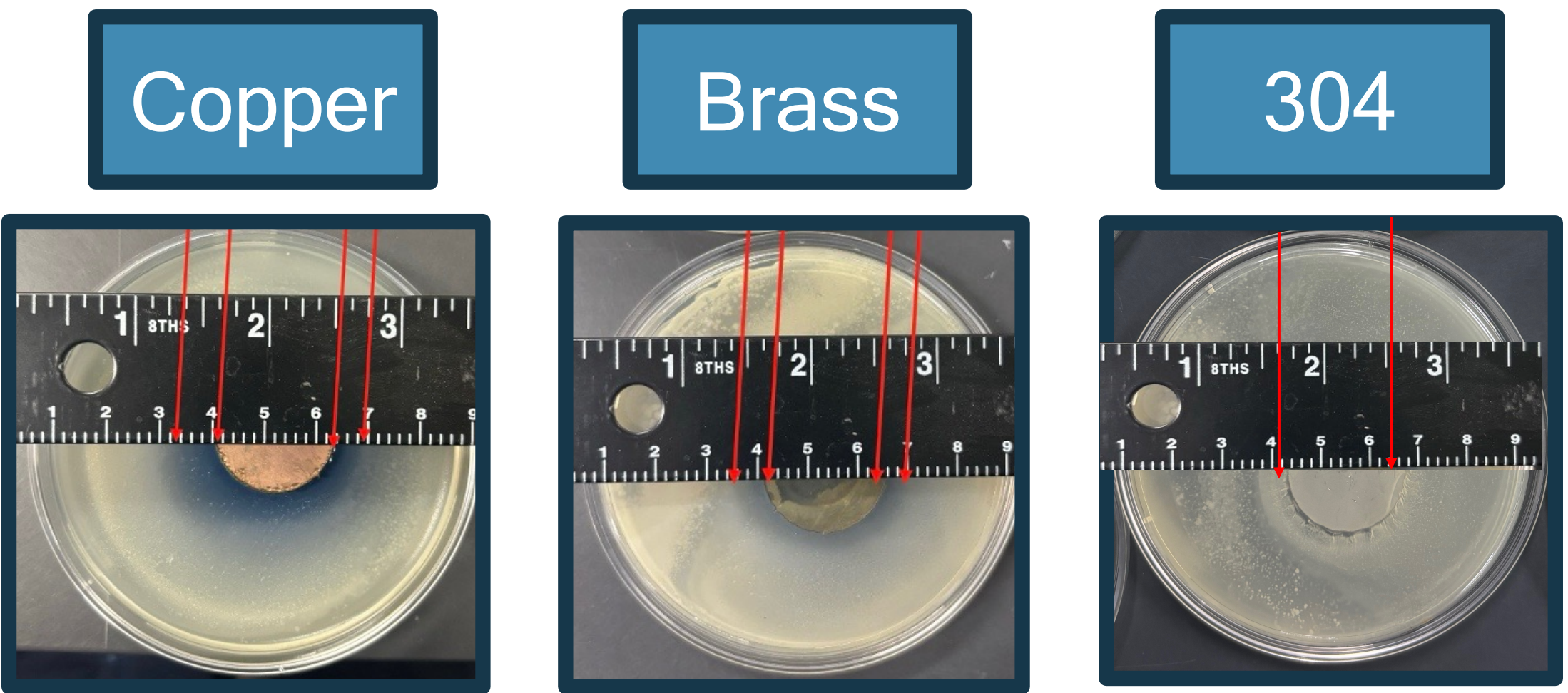
Mechanism

Copper, brass, and bronze exhibit antimicrobial properties against *E. coli* through ion release and oxidative stress. Copper ions penetrate bacterial membranes, causing cell lysis and metabolic disruption. Stainless steel has less antimicrobial potential.

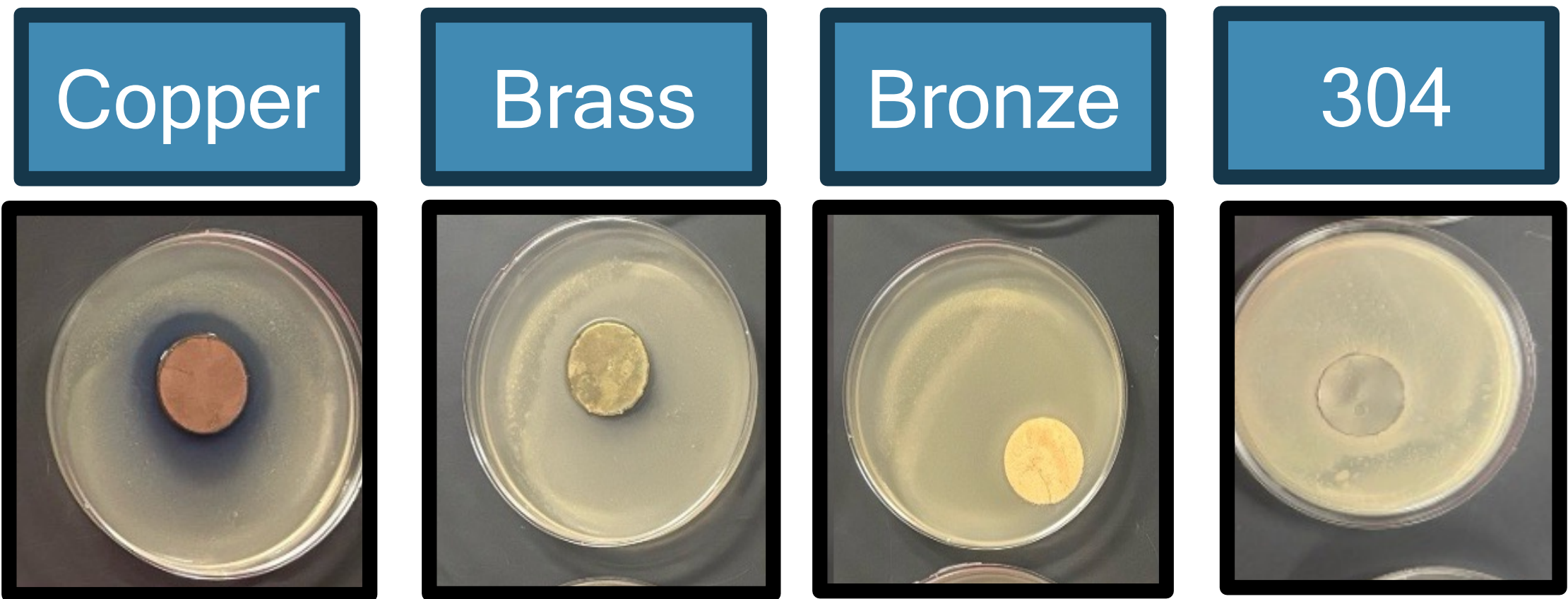


Method - Inhibition Zones

- Symmetric circular coupons were made using a 1-inch metal punch.
- E. Coli* was cultivated in 50 mL Falcon tubes for 24 hours at R.T.
- Cells were plated to generate a lawn with 50 mL of culture to each plate.
- Plates were held 24 hours at room temperature.
- Inhibition zones were measured as shown below.



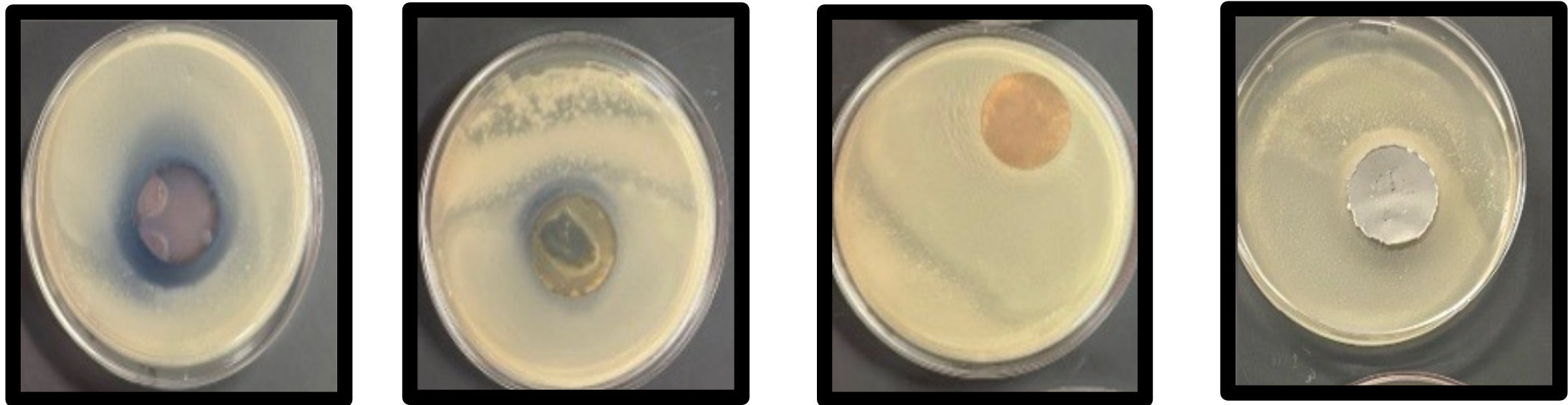
Base Metal Test Phase



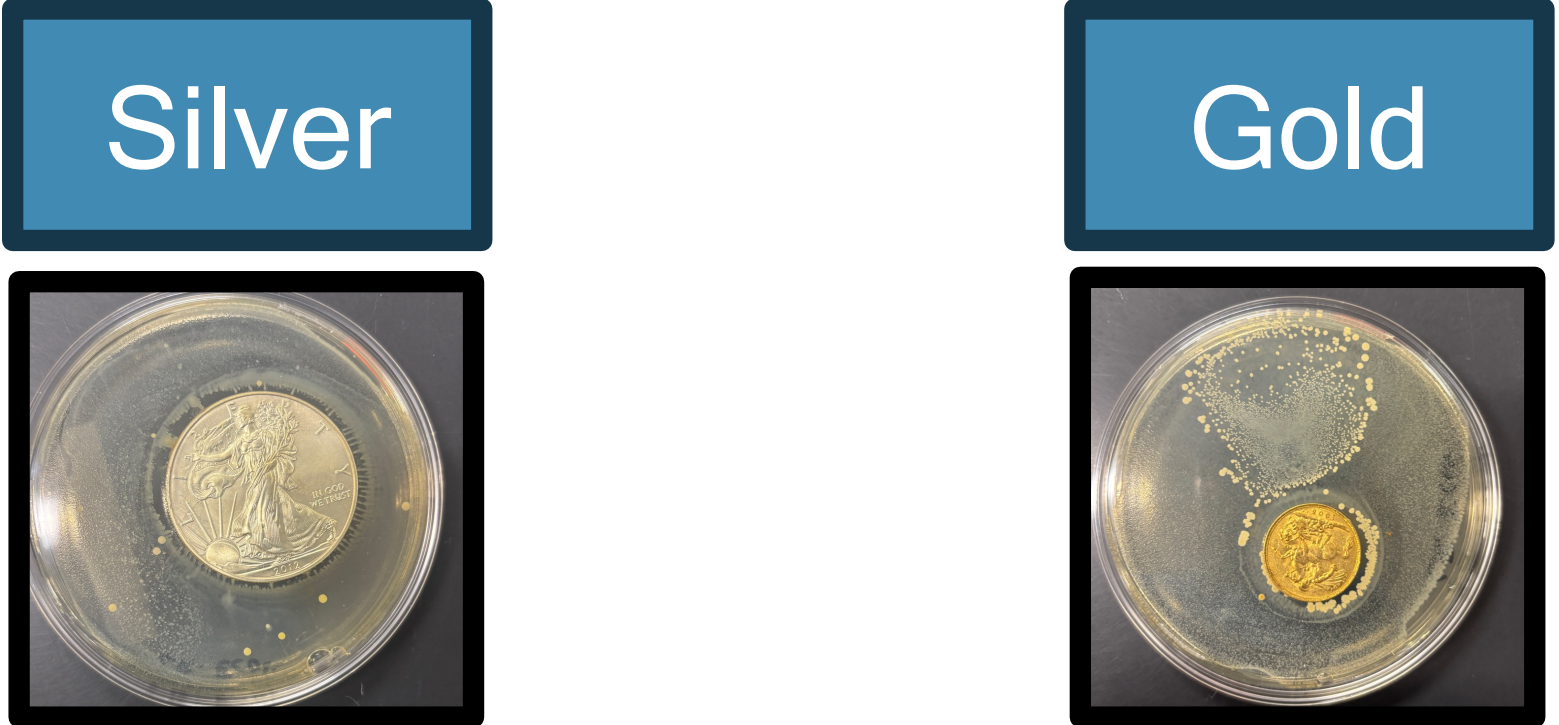
Method - Pre-Oxidation

- Coupon oxidation with 24 hours in water and then 24 hours air drying
- Cells plated with the same procedure above.
- Inhibition zones measured as shown above.

Pre-Oxidized Test Phase



Silver/Gold Test Phase



Results

Metal Sample	Base Metal
Copper	10 mm
Silver	5 mm
Gold	4 mm
Brass	2 mm
Bronze	0 mm
Stainless Steel	0 mm
Control	0 mm

Metal Sample	Oxidation Status	Pre-Oxidized	Average	Standard Deviation
Copper	Most Oxidized	18 mm	16.3	2.9
Brass	Moderate Oxidation	6 mm	4.7	1.5
Bronze	Less Oxidized	0 mm	0 mm	0 mm
Stainless Steel	Least Oxidation	0 mm	0 mm	0 mm

Conclusions

Copper content correlated directly with antimicrobial effectiveness. Phosphorus may explain bronze deviation from the trend. Silver and gold inhibition may correspond with their relation to copper in the periodic table.

Future Work

- Silver and gold effectiveness relative to copper.
- Impact of hardeners on Cu integrity and effectiveness.
- Impact of Cu and metals on viruses and fungi.

Acknowledgments

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References

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