



In partnership with



Wilson College  
of Textiles

# PPE Surface Chemistry and Surface Interactions

Webinar Series on PPE Production and Design  
Part 7

Sponsors



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June 23, 2020

# Challenge Barrier and Agents (System)

## Challenge Agent

### Liquid

Viscosity

Surface Tension

### Particle

Lint/Dust

Microorganism

Size

Shape

## Barrier

### Surface

Fiber

Smoothness

Finish

Surface Energy

### Material

Yarn

Construction

Pore Size & Distribution

Thickness

# Surface Interactions

Challenge Agent

Barrier

Liquid

Viscosity

Surface Tension



Surface

Fiber

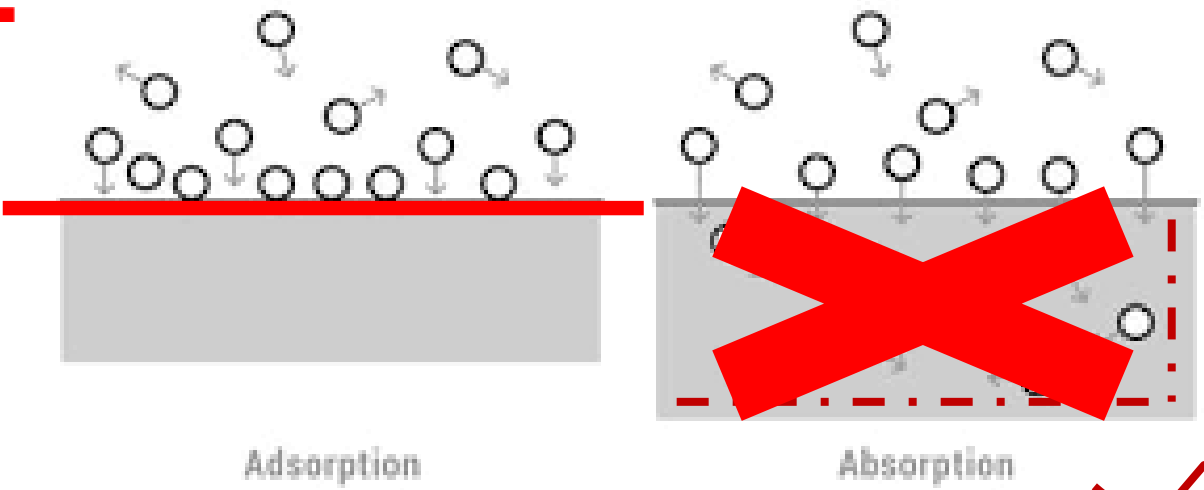
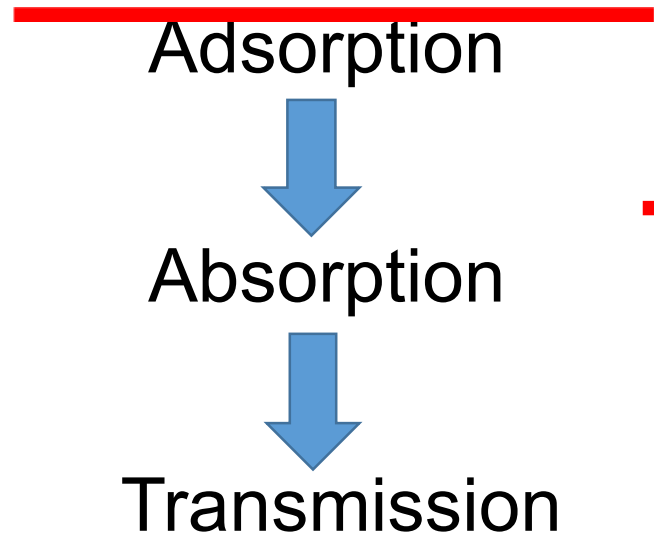
Smoothness

Finish

Surface Energy

Barrier

So if can prevent adsorption, will prevent absorption/transmission



← Create a tortuous path\*

*\*Look for structures that increase impingement/contact. Especially critical if using antimicrobials*

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Challenge Agent

Liquid

Viscosity

Surface Tension

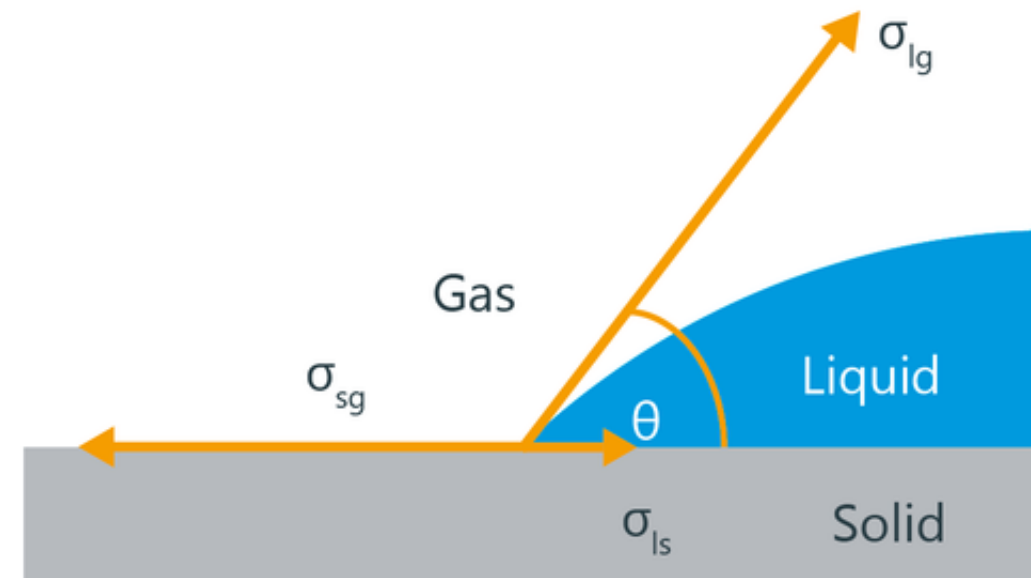
## Interaction between Liquid and Solid

whether it

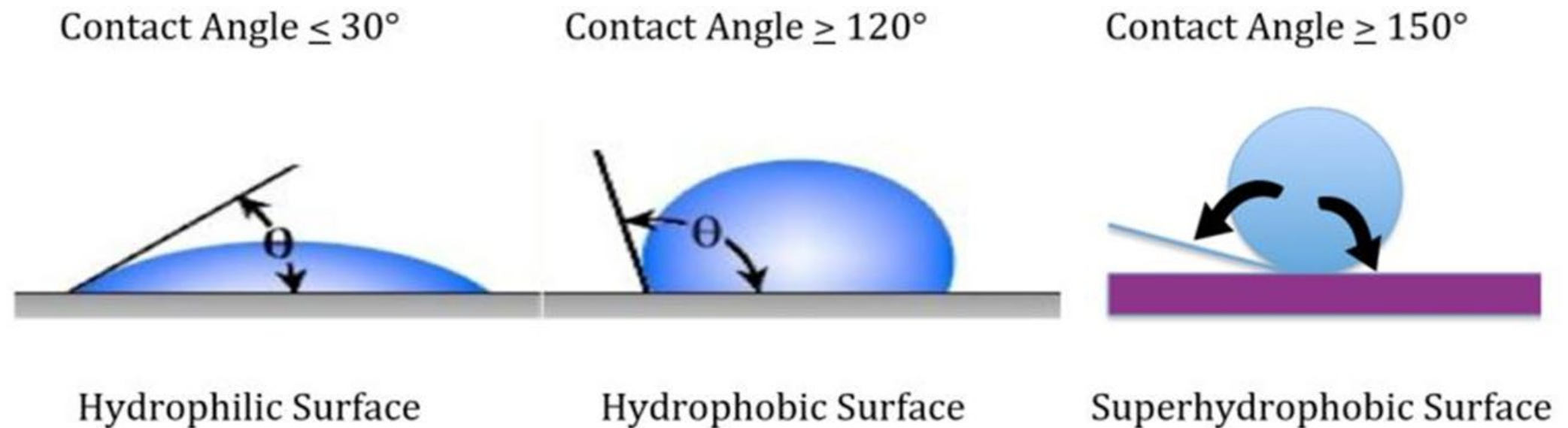
- rolls up and off of the surface
- sits on the surface
- spreads on the surface

is controlled by the **Interfacial Tension**

$$\gamma_{sv} = \gamma_{sl} + \gamma_{lv} \cos \theta_Y$$



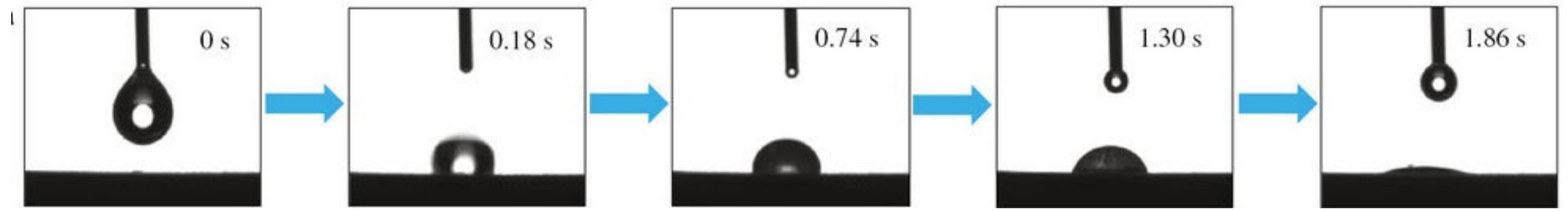
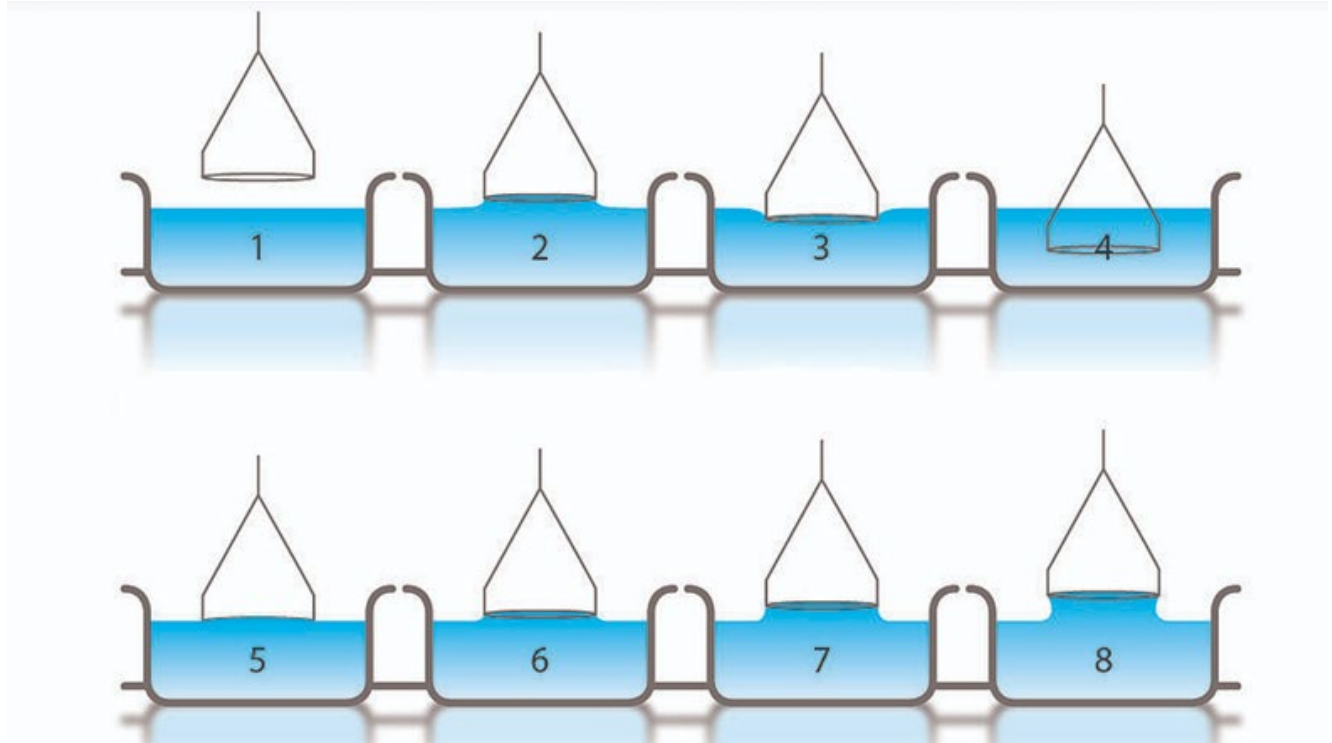
- Surface interaction between solid and liquid – interfacial tension
  - **Contact Angle  $\Theta$**
- If the contact angle is less than  $90^\circ$ , then it is said the liquid wets the surface



# Measurement

- Both **Optical** and **Force Tensiometers** used for
  - Static
    - Goniometer
    - Du Noüy Ring
    - Wilhelmy Plate
    - Bubble Pressure
    - Pendant Drop
  - Dynamic







If surface energy is less than surface tension of liquid, then will spread

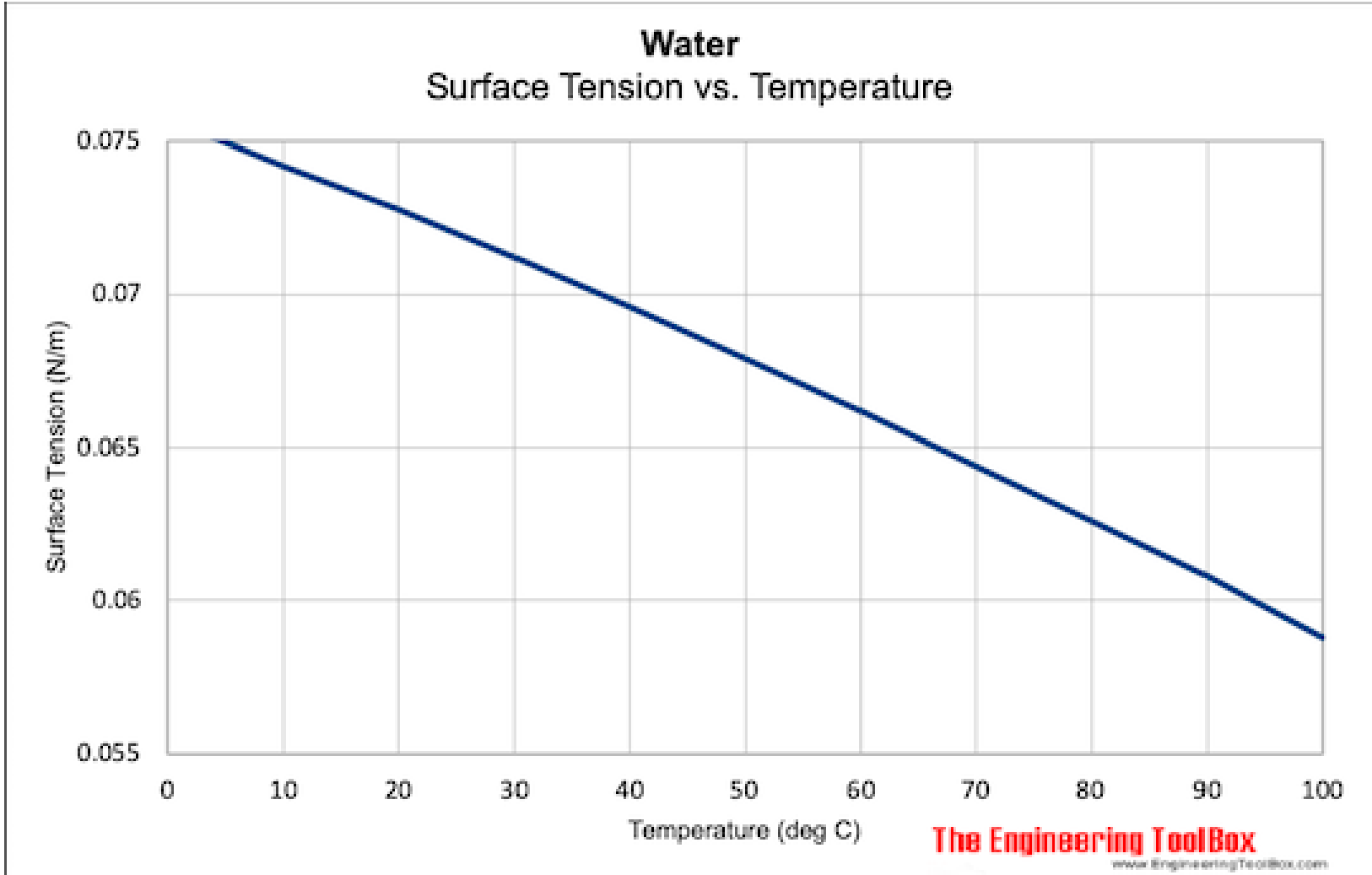
**Surface Tension of Liquids at 20°C\* (dyne/cm)**

- Water 72
- Physiological Saline ~71
- Blood ~50
- Oil ~30-35
- Alcohol (Isopropyl) ~23

**Surface Energy of Polymers used in Textiles (films) (mN/m)**

- Polytetrafluoroethylene ~19-20
- Polyethylene ~30-35
- Polyester (PET) ~44
- Nylon 6,6 ~46
- Nylon 6,12 ~41

<https://pubs.acs.org/doi/pdf/10.1021/bk-2009-1019.ch012>



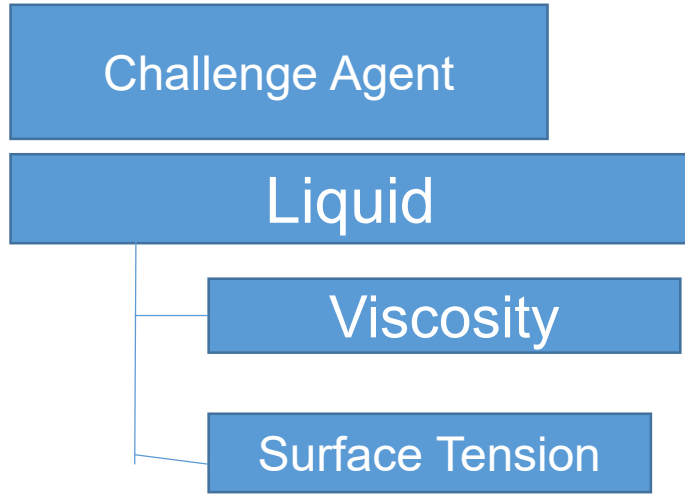
To alter the liquid / surface interaction, common modifications are made:

To reduce the liquid's surface tension – Surfactants can be added;

- Commonly used to aid in cleaning process
- Reduce surface tension to allow for penetration into fabric/fibers

Finishes are applied to textile surfaces to decrease the surface energy to improve repellency

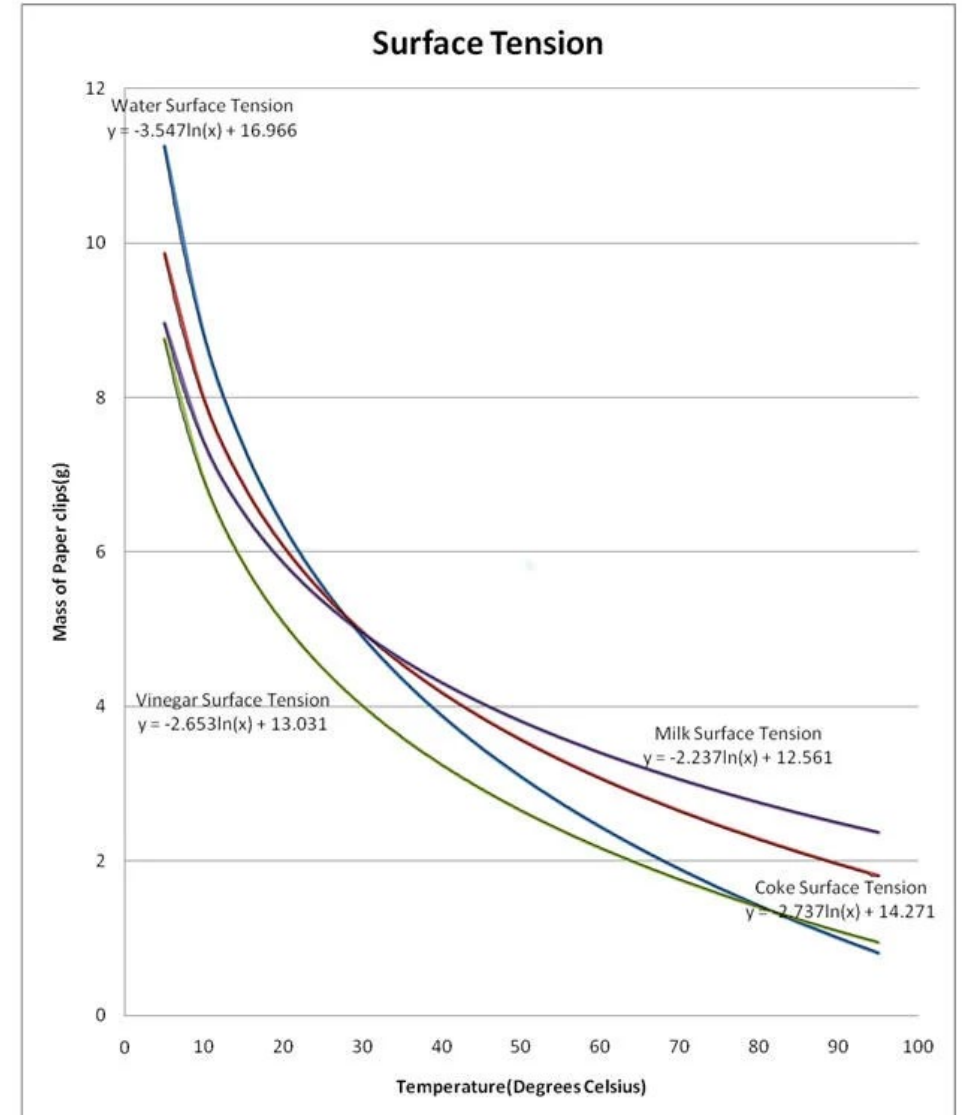
- Fluorocarbon 19-20
- Paraffin Waxes 23
- Fatty Acids 24
- Polymethylsiloxane Film 26



## Viscosity\*

- A measurement of thickness and stickiness of a liquid (blood)

- The more viscous the liquid, the higher the 'stickiness' so will cling to surface
- Resistance to flow
- Viscosity decreases as temperature increases
- Surface Tension increases as viscosity



Barrier

Surface

Fiber

Smoothness

Finish

Surface Energy

## Fiber

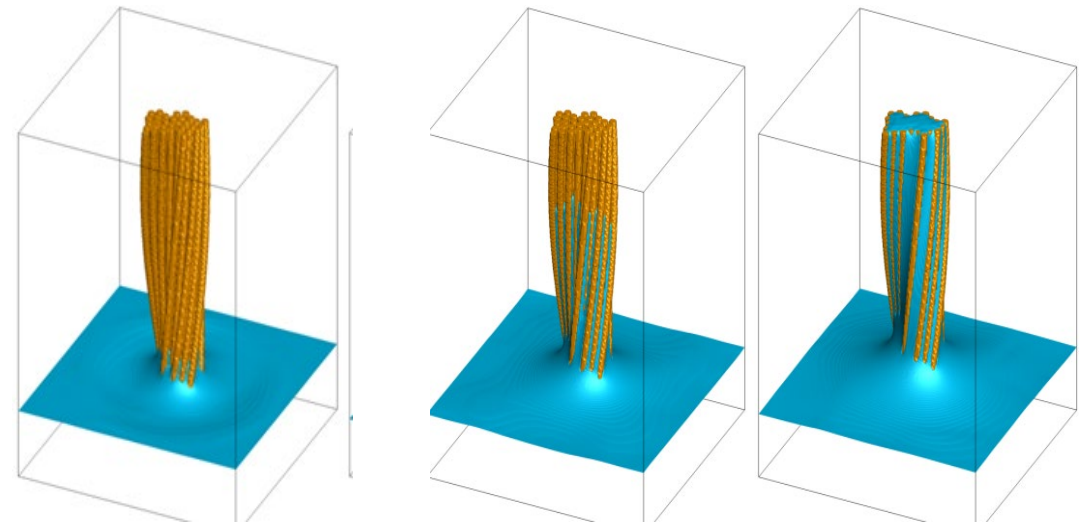
- Chemical
  - Hydrophilic
  - Hydrophobic
- External Morphology
  - Irregular
- Size (diameter)

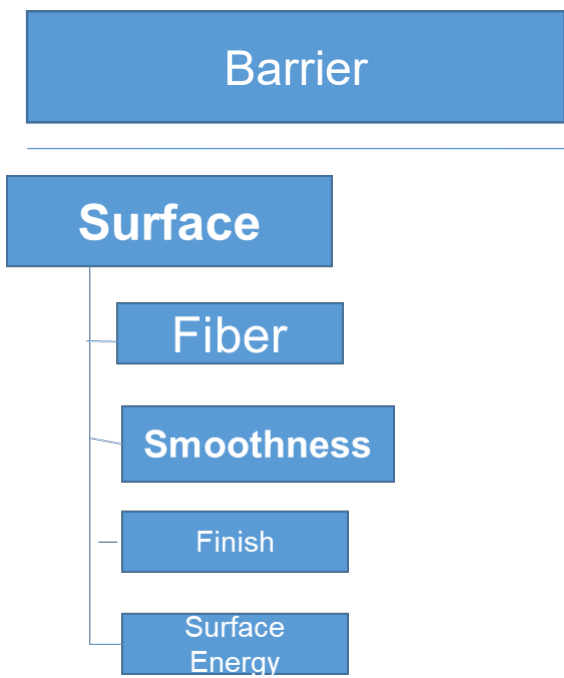
## Smoothness

- Fiber
- Fabric Structure
- Yarn Structure

## Capillary Action

- ability of liquid to flow in narrow spaces without assistance of external forces



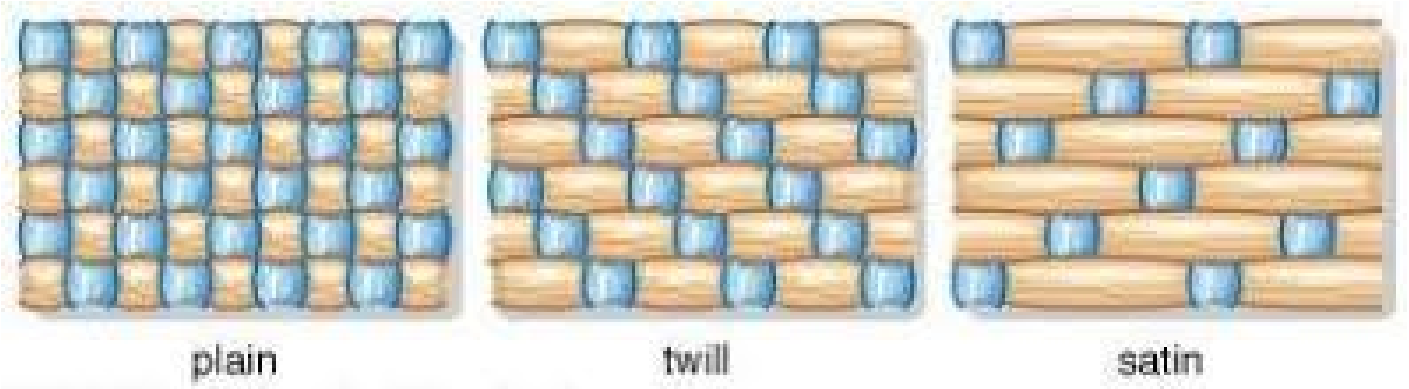
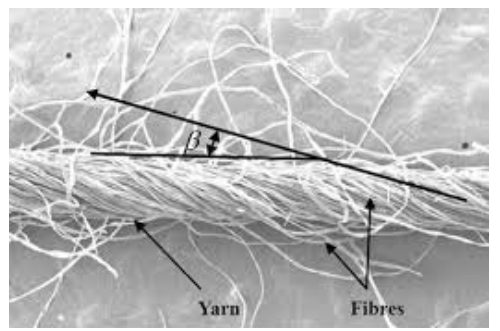
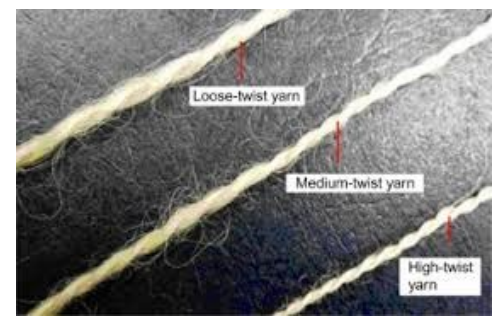


# Yarn

- Fiber Length
  - Staple - protruding fibers
  - Filament – smooth

# Fabric

- Construction/Weave
- Thread Count



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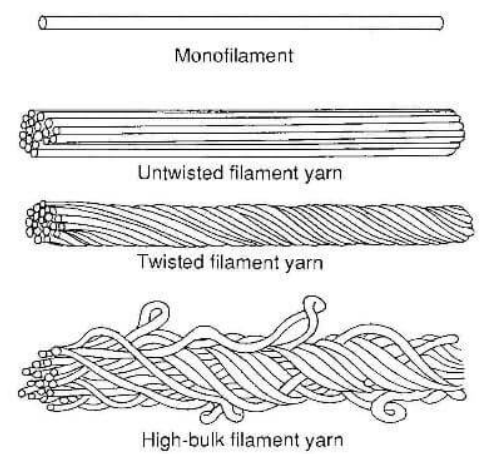
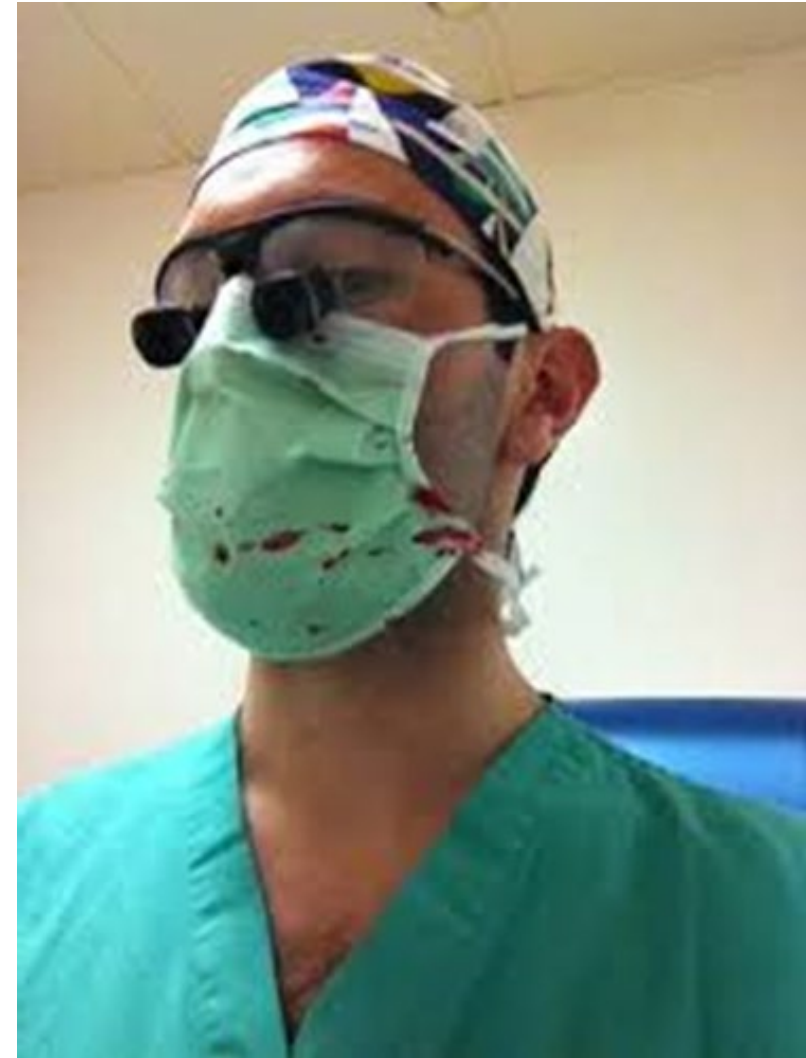
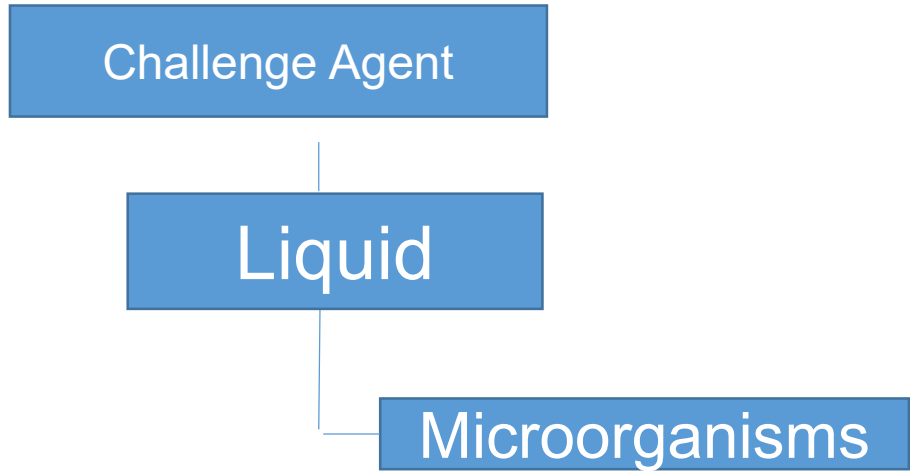
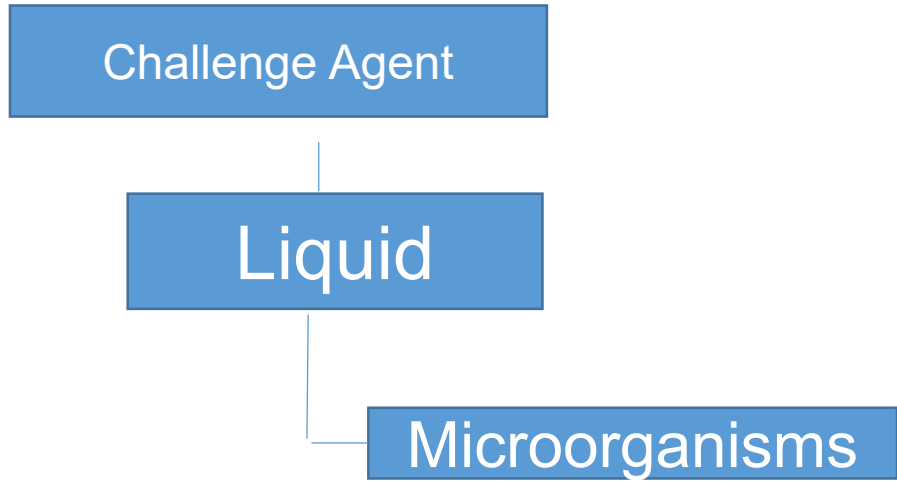


Figure 2. Structural geometry of filament yarns.

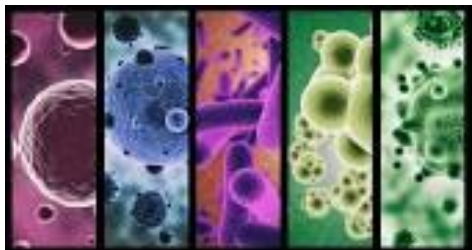






## Microorganisms

- Bacteria
  - Gram +                  Gram –
- Virus
  - Filamentous    isometric (or icosahedral),
  - enveloped        head and tail.
- Fungi
  - Chytridiomycota , Zygomycota
  - Ascomycota Basidiomycota





# Finishes - Antimicrobials

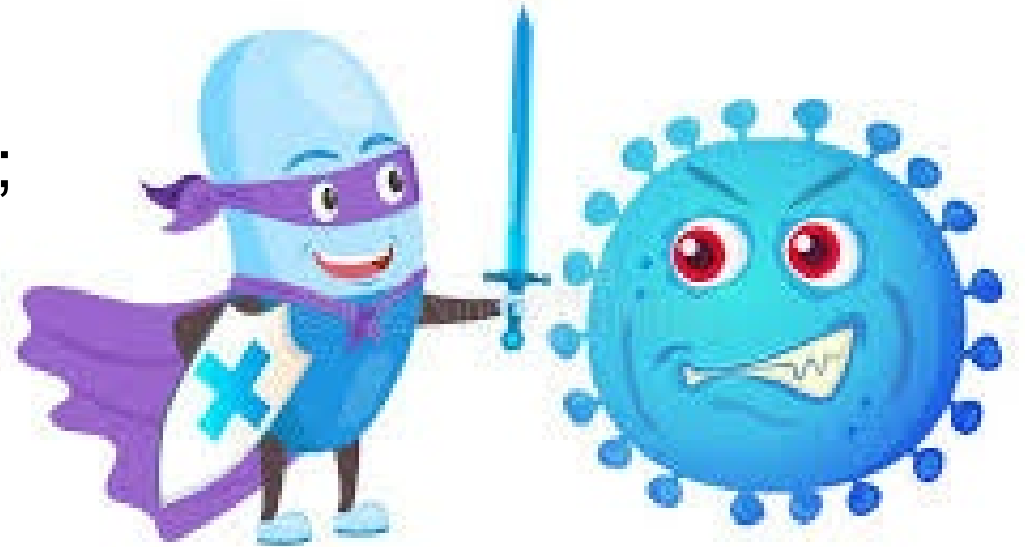
Antimicrobial products kill or slow the spread of microorganisms



Microorganisms include bacteria, viruses, protozoans, and fungi.”

# Ideal Antimicrobial Polymer

- highly stable over long periods of time;
- be easily and inexpensively synthesized;
- not decompose or emit toxic products;
- water insoluble for disinfection of water;
- broad spectrum;
- non-toxic and non-irritating.



# Antimicrobials

**Specific antimicrobials** are effective for **specific microorganisms**

Mechanisms vary

- inhibit cell wall synthesis,
- depolarize cell membrane,
- inhibit protein synthesis,
- inhibit nucleic acid synthesis,
- inhibit metabolic pathways in bacteria



***Are effective when*** microorganism ***comes into contact*** with antimicrobial  
***for a period of time***

# Antimicrobial groups by action mechanism

## Inhibit Cell Wall Synthesis

- $\beta$ -Lactams
  - Carbapenems
  - Cephalosporins
  - Monobactams
  - Penicillins
- Glycopeptides

## Depolarize Cell Membrane

- Lipopenpides

## Inhibit Nucleic Acid Synthesis

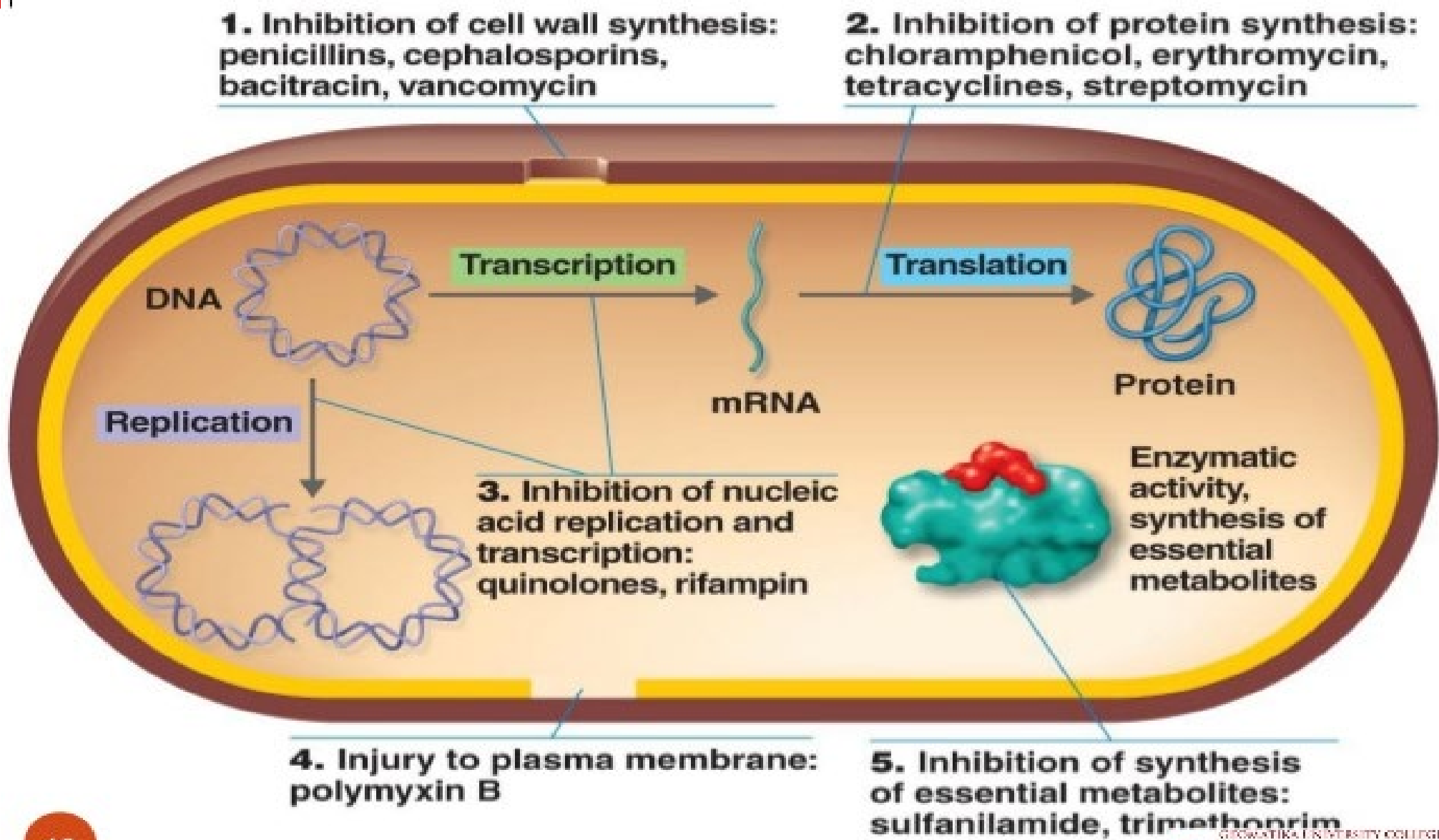
- Quinolones
  - Flroroquinolones

## Inhibit Protein Synthesis

- Bind to 30S Ribosomal Subunit
  - Aminoglycesides
  - Tetracyclines
- Bind to 50S Ribosomal Subunit
- Chloramphenicol
  - Lincosamides
  - Macrolides
  - Oxazolidnones
  - Streptogramins

## Inhibit Metabolic Pathways

- Sulfonamides
- Trimethoprim



## Inhibition of Cell Wall Synthesis

- One of the most common pathways
  - appealing absence of counterparts in human biology, thereby providing intrinsic target selectivity.

## Inhibit Protein Synthesis

- Multi-step process
  - involves many enzymes
  - conformational alignment
- Attacks
  - formation of the 30S initiation complex
  - formation of the 70S ribosome by 30S initiation complex & the 50S ribosome
  - The elongation process of assembling amino acids into a polypeptide

## Depolarize Cell Membrane

- Membrane potential becomes less negative (more positive). ...
- Opens channels letting positive ions flow into the cell

## Inhibit Metabolic Pathways

- target nucleic acids and amino acid synthetic pathways.
- Interferes with Folic acid (Tetrahydro-folic Acid [TH4]) metabolism
  - Targets two adjacent steps

## Inhibit Nucleic Acid Synthesis

- Inhibit enzymes required for bacterial DNA synthesis.
- inhibit DNA replication.

# Surface Interactions

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*Thank You!*

*Questions??????*

