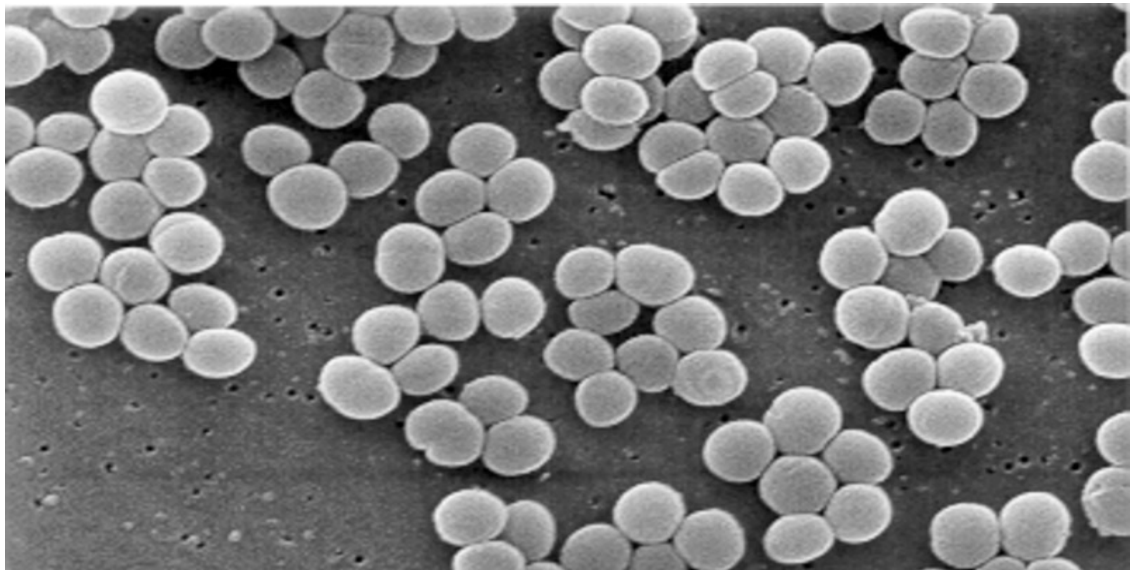
Staphylococcus aureus bacteria

- *S. aureus* are cocci shaped (round) bacteria
- *S. aureus* are non-motile (no flagella)
- *S. aureus* are commonly found as harmless commensal bacteria on human skin.



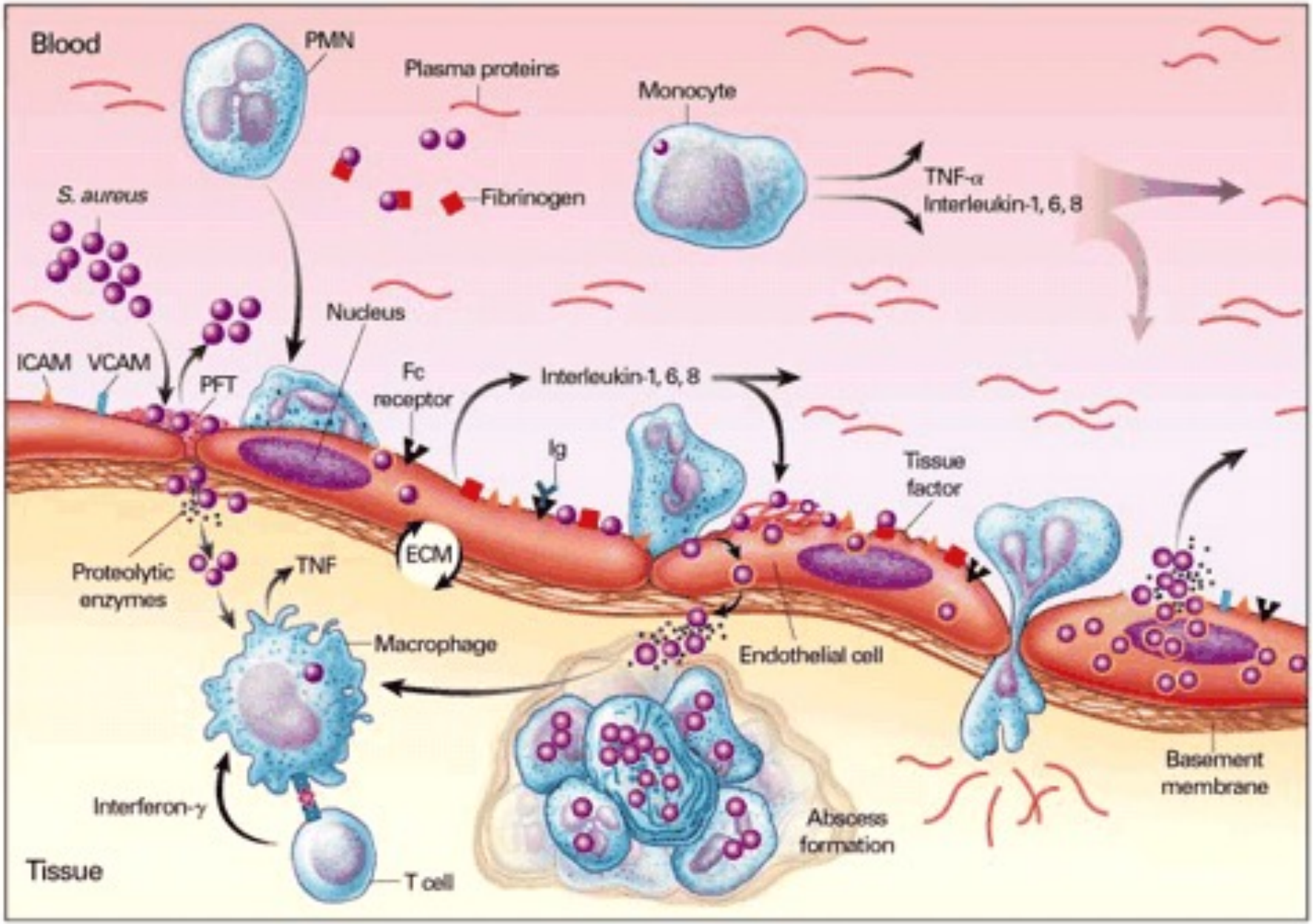
However, *S. aureus* bacteria can inhabit nasal passages of up to 40% of humans without causing disease!

S. aureus can be an **opportunistic pathogen.** This means <u>when the bacteria are able to invade tissues (get under skin or into blood), they can cause disease.</u>

Staphylococcus aureus

- *S. aureus* bacteria replicate extracellularly and use fast replication + toxins to survive in host.
- Despite being regarded as an extracellular bacterium, ***S. aureus* can invade and survive within human cells.**
- The intracellular niche provides evasion from the immune system, antibiotic treatment and allows bacterial proliferation.
- Host cell exit is associated with cell death, tissue destruction, and the spread of infection.

S aureus invades tissues and blood



Staphylococcus aureus Toxins

- Toxins are virulence factors released by bacteria to provide better survival for the bacteria in the host.
- Most toxins cause damage to host or access to other tissues in host or immune evasion or better transmission.
- Common toxins secreted by *S. aureus* are **hemolysin, leukotoxin, exfoliative toxins, enterotoxins, and toxic-shock syndrome toxin-1 (TSST-1).**
- Aside from toxins, staphylococcal virulence factors also include enzymes and surface proteins.

Diseases caused by *Staphylococcus aureus* (non-healthcare associated diseases)

Local skin infection

pimples, boils

Toxin-mediated diseases

1. Impetigo
2. Staphylococcal Scalded Skin Syndrome
3. Staphylococcus toxin-mediated food poisoning
4. Toxic Shock syndrome
   menstrual
   nonmenstrual

Impetigo

Crusted impetigo

Impetigo is a skin infection in children or adults that is primarily caused by *S. aureus.*
Disease triggered by exfoliative toxin (protease that breaks down layers of epidermis) leading to blistering and crusting.

Impetigo is treated with antibiotics.

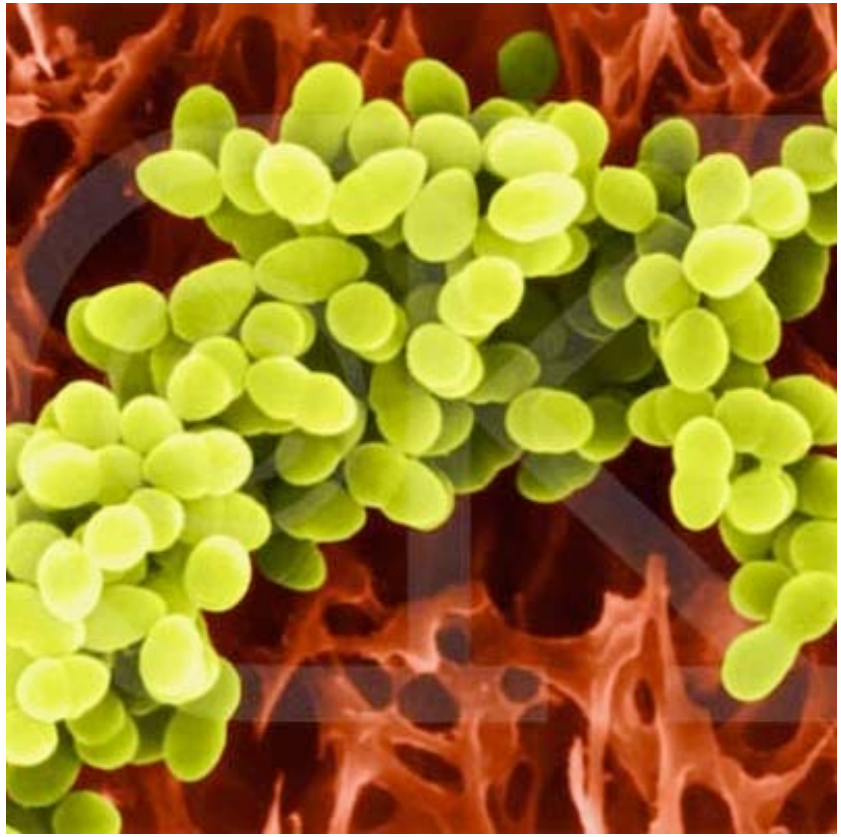
Staphylococcal Scalded Skin Syndrome (SSSS)

Disease is mediated
By another **exfoliative toxin**
-kills skin cells, primarily in children

Staphylococcus toxin-food poisoning

Disease with symptoms mediated by toxins that can act as superantigens

- enterotoxins SEA, SEB, SEC are toxins, but viable bacteria are not necessarily found in the contaminated food
- toxins are heat stable
- no fever but severe nausea, vomiting



Diseases caused by *Staphylococcus aureus* In healthcare settings

- **Bacteremia** or sepsis when bacteria spread to the bloodstream.
- **Pneumonia,** usually found in patients with underlying lung disease and/or on mechanical ventilators.
- **Endocarditis** (infection of the heart valves), which can lead to heart failure or stroke.
- **Osteomyelitis (bone infection),** can happen after bacteremia or surgery/injury.

Toxic shock syndrome

- “Toxic shock syndrome” (TSS) first used in 1978 to describe staph outbreak in children. However, Staph bacteria could not be isolated from blood, indicating a toxin might be involved
- In January 1980, epidemiologists in Wisconsin and Minnesota reported the appearance of TSS (unexplained acute fever, vomiting, rash and a high number of deaths) mostly in menstruating women, to the CDC.
- *This time Staph bacteria were cultured from most of the women
- Sept 1980: CDC epidemiology identified that users of Rely tampons were at greater risk to get TSS.

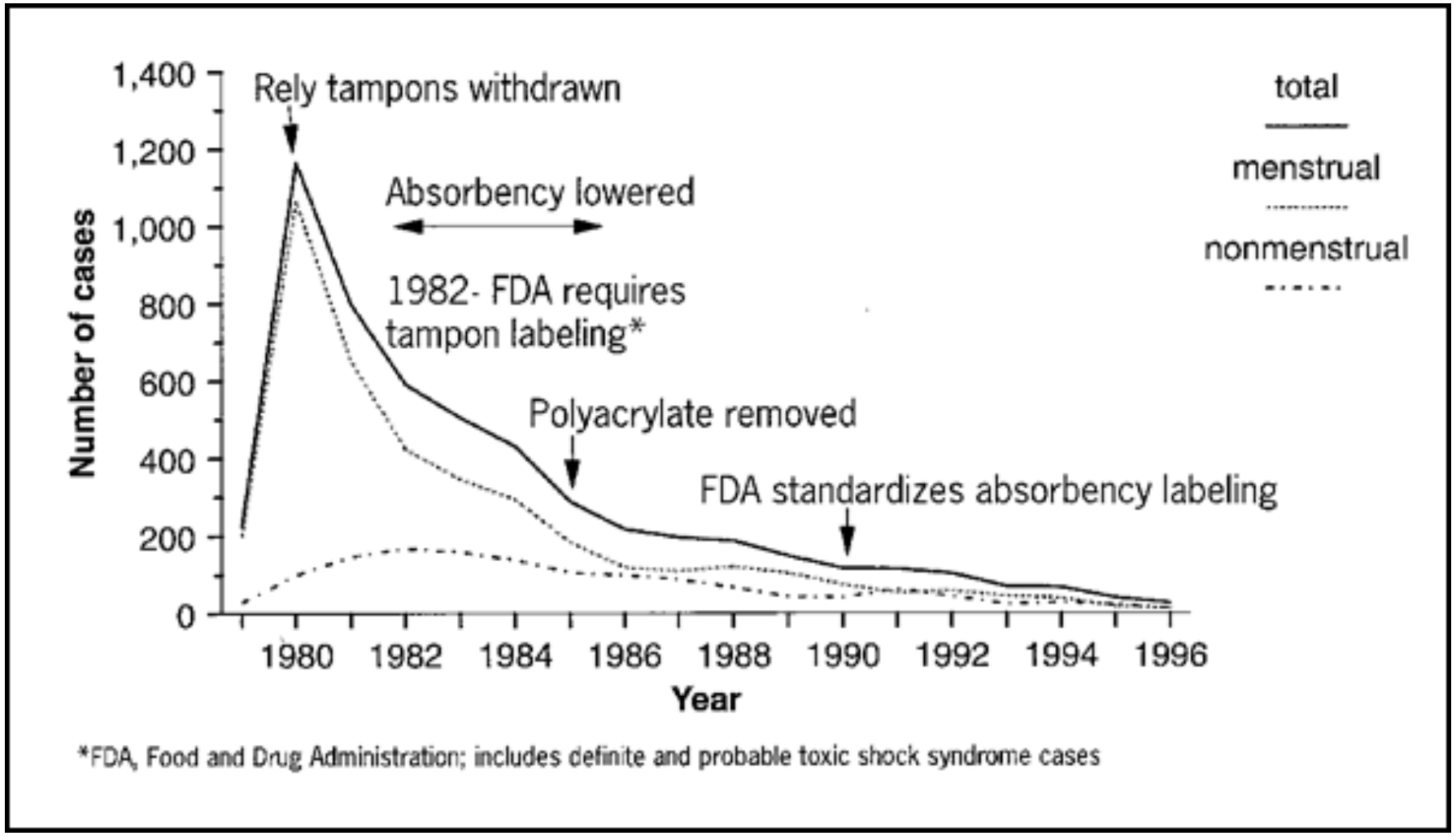
A brief history of tampons

- Tampons were developed in 1936 and became popular quite quickly; 90% were sold by Tampax
- By 1960 tampon usage was widespread within the US
- But there were no regulations from US federal or state health agencies on tampon composition or production.

- To compete with Tampax other companies started marketing for “increased protection” by making “super-absorbent” tampons made with **synthetics**, **not cotton**

- Rely tampons introduced in 1979 were made with polyester and carboxymethyl cellulose.

Toxic Shock Syndrome in the United States: Surveillance Update, 1979–1996



cdc.gov

Excessive absorbency led to altered "microbial ecosystem" in the vagina

- viscosity of vaginal fluids increased
- increased bacterial growth
- emergence of new strain of *Staphylococcus aureus* secreting a new toxin called toxic shock syndrome toxin-1 (TSST-1) now found in approx. 20% of *S. aureus* isolates
- 208 deaths from 5296 cases from 1979-1996 but not ALL were menstrual TSS.

Two forms of Toxic Shock Syndrome (TSS) both mediated by toxins called “superantigens”

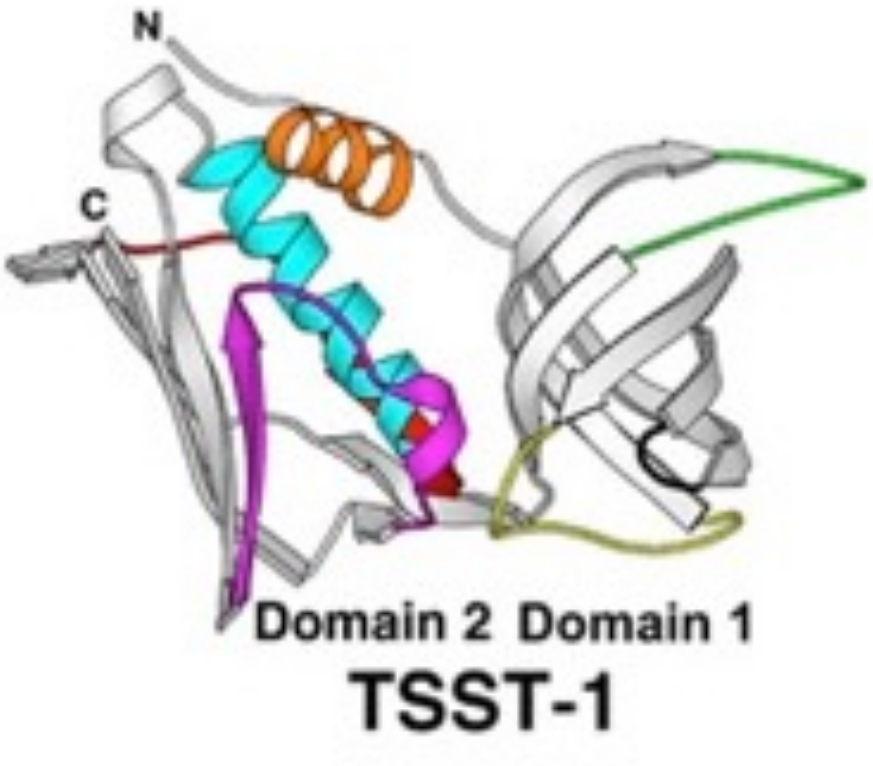
Menstrual TSS:

- Starts within 2 days of beginning or end of menses
- associated with high absorbency tampons
- TSST-1 (Crosses mucosal membranes!) isolated from >95% cases

Nonmenstrual TSS:

- similar to menstrual TSS, but caused by colonization of various sites (lung, skin, surgery)
- wounds themself don’t seem to be inflamed
- can be caused by TSST-1 (<50%) or other toxins (also superantigens)

In both cases proper treatment results in mortality of <5%
-complicated due to antibiotic resistance



Superantigens

The toxins responsible for TSS and Staph mediated food poisoning are superantigens meaning they cause non-antigen specific mediated inflammation

How do superantigens work?

By activating lots of T cells to make lots of cytokines to activate lots of macrophages to make more cytokines and create inflammation

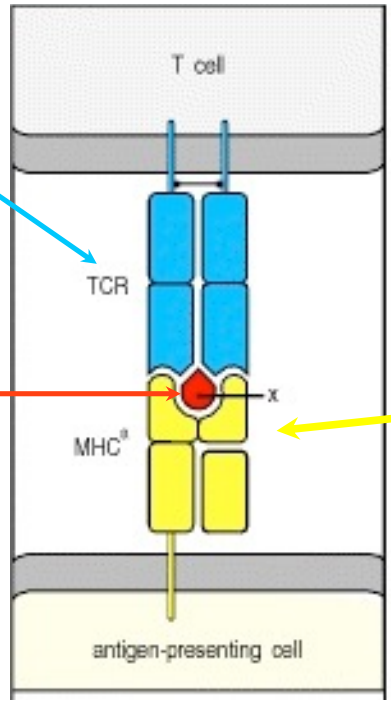
Thelper cells drive usual immune response

Normally, less than 0.01% of T-cells will respond to a given pathogen
Therefore, during an infection with a specific pathogen, very few T cells normally respond (most are specific for *other* pathogens)

This is from adaptive immunity lecture.

T Cell Receptor

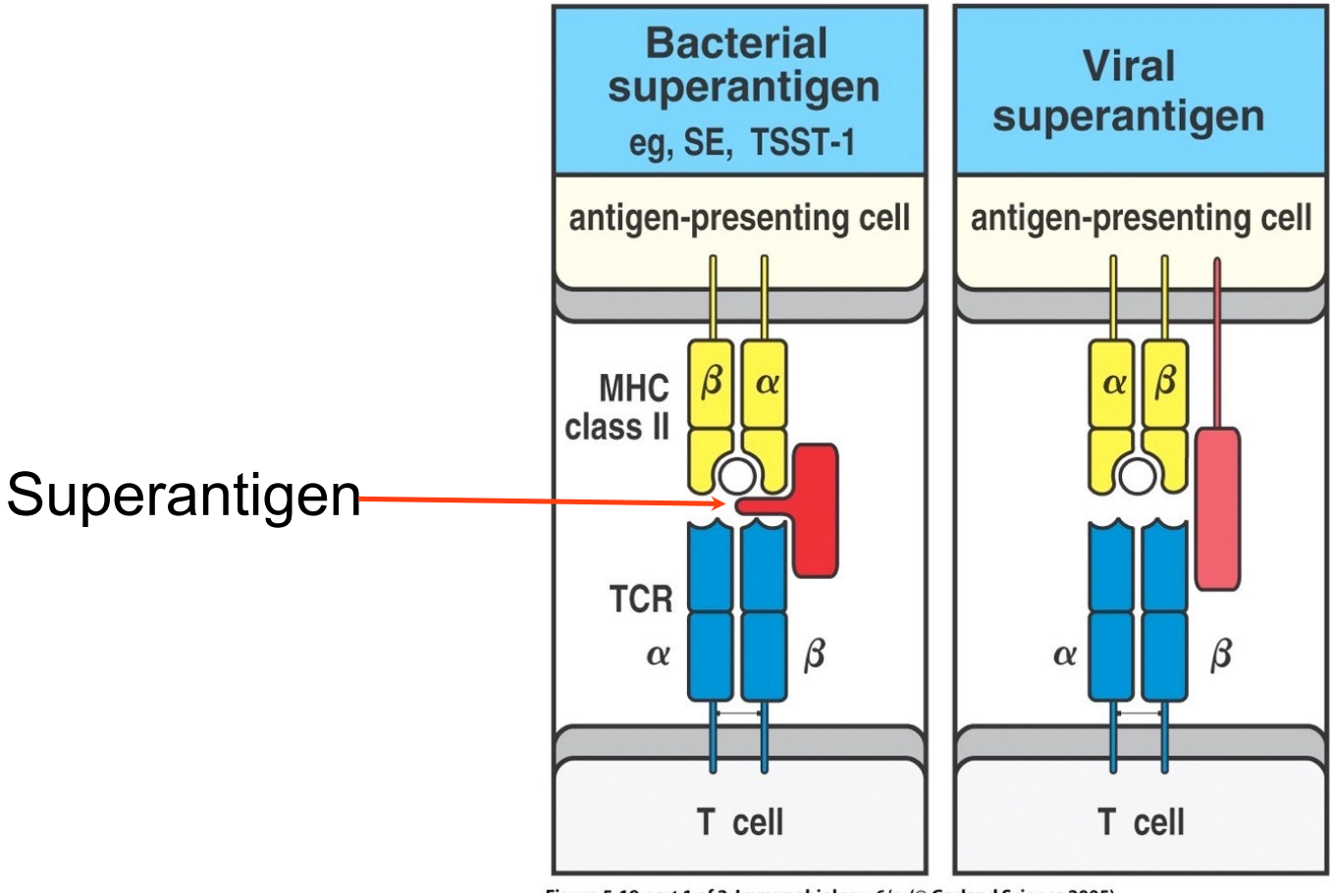
antigen (e.g. from virus)



MHC display antigens to T cells

T-cell receptor recognition of antigen leads to T cell activation and thus cytokine production and activation of the immune system

“Superantigens” are proteins made by some pathogens that nonspecifically “glue” the T cell receptor (TCR) to the MHC, regardless of the specific peptide present



Nonspecific activation of a large percentage of T helper cells results in excessive cytokines from Th cells to trigger inflammatory cytokine production by macrophages which can be highly toxic