Microbe of the month

Breaking The Chain of Infection

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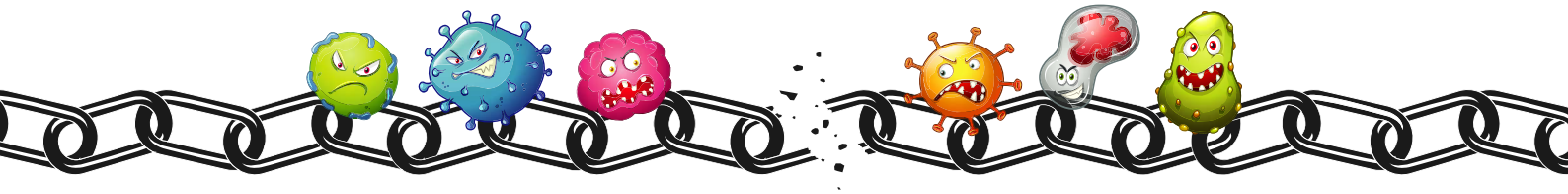
APRIL 2019
Newsletter
Compiled by Helen Loudon, Independent IPC Practitioner



Featured this month:

Back to Basics

ALL ABOUT BACTERIA (Part 2) Ensuring survival at all costs

As with all living creatures, bacteria need food and water for growth and multiplication. Most will not survive for long on clean, dry surfaces, but will readily multiply on poorly-cleaned equipment, in contaminated food and water, and even in solutions of disinfectant.

This issue discusses the clinical relevance of bacterial reproduction, how they adapt to extreme physical conditions, cleverly exchange genetic material to ensure the survival of the species and their aptitude for antimicrobial resistance.

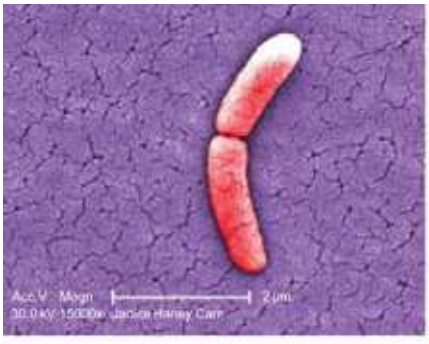
BACTERIAL REPRODUCTION: a lonely affair, and their offspring are identical copies

Bacteria reproduce asexually, by a process known as **binary fission**.

The cell grows in size, elongating to about twice its original length, and then divides into two identical cells. Once division is complete, bacteria grow and develop the features which make each species unique.

The interval of time until the completion of the next division is known as the 'generation time' or 'doubling time'. Under ideal environmental conditions, growth and division can occur rapidly, with some bacterial cells dividing *exponentially every 20 minutes* (e.g., E. coli). The 'generation' or 'doubling time' for *Staphylococcus aureus* is approximately 30 minutes, about 18 hours for Mycobacterium tuberculosis (the bacillus which causes TB) and 33 hours for Treponema pallidum (*syphilis spirochete*).

Clinical relevance? The 'generation time' time therefore explains and helps to determine the amount of time that passes before symptoms of disease appear in an infected individual.



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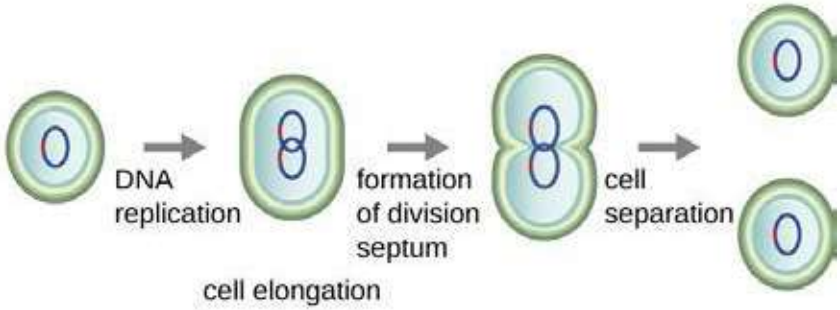


(b)

Reproduction by binary fission lends a certain *immortality* to bacteria, because there is never a moment at which the first bacterium has died. With binary fission, a single E. coli rod could replicate (divide) itself at least one billion times in a 10-hour period!

The chromosome contains all the information necessary for cellular activities and to enable the bacterium to replicate itself. When the cell divides, a copy of the chromosome is made for the new 'daughter' bacterium, and so on.

It is important to note that bacteria often carry extra genetic material in the form of small circular pieces of DNA called plasmids. Plasmids are also duplicated and transferred to each new cell during binary fission, *but they can also replicate independently* – this is a key aspect of how genetic material is exchanged between bacteria (including antibiotic resistance). This will be discussed further on in the text under **bacterial genetics**, in the section on 'conjugation'.

Most bacteria can make many of the substances needed to build and operate the cell (the reader is encouraged to review the MOM for March 2019), but aside from water, essential nutrients include a source of carbon (required for cell structure and energy), nitrogen to make proteins and nucleic acids (DNA, RNA), and various inorganic ions such as phosphate, sulphur, calcium and iron to make amino acids and to promote enzyme activity.

THE ROLE OF OXYGEN in bacterial cell metabolism

How bacteria deal with oxygen is a major factor in their microbiological classification. Many differ in their requirements for oxygen depending on the mechanism they use to make energy. Some species of bacteria can only grow in the presence of oxygen and are called '*obligate aerobes*'; others are *obligate anaerobes* and will die rapidly if exposed to air.

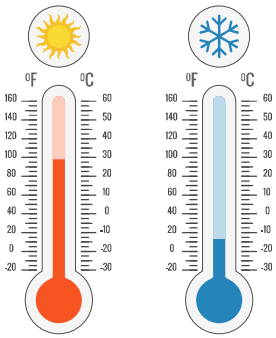
Clinical relevance? Anaerobic bacteria are present in large numbers in the bowel and may cause devastating infection if intestinal contents are spilled during surgery. Anaerobic bacteria are also associated with contaminated traumatic injuries, necrotic wounds or those with a poor blood supply (e.g., diabetic foot ulcers, Category 4 and unstageable pressure ulcers).

Some bacteria are neither aerobic nor anaerobic, and are termed ***'facultative'***. Facultative bacteria can grow in either the presence, or a reduced concentration, of oxygen.

Facultative anaerobes: Don't let this name fool you! These bacteria actually prefer aerobic conditions, but, if conditions dictate, they are able to grow in the absence of oxygen by using fermentation for energy (this could be compared to the switch to anaerobic glycolysis that human muscle cells undergo during sprinting).

This group includes many *Staphylococci, Streptococci* and a variety of intestinal rods (e.g., *E. coli*). Certain facultative anaerobic bacteria use sulphur in their metabolic activities instead of oxygen, and therefore produce hydrogen sulphide rather than water as a by-product. Others make considerable amounts of methane gas.

Clinical relevance? If a wound and exudate are purulent and have a strong odour of rotten eggs, it is likely that high numbers of the Gram-negative bacterium *Proteus mirabilis* are present and causing an infection. Thorough wound cleansing and the use of antiseptic / antimicrobial dressings would probably be indicated.



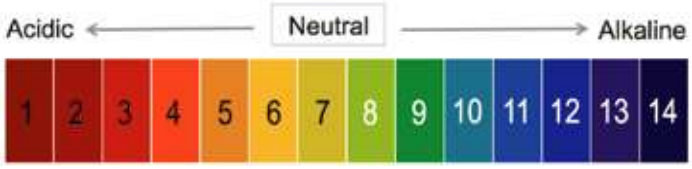
TEMPERATURE AND BACTERIA – anything goes

Bacteria inhabit almost every environment on Earth due to natural evolution and their unique ability to tolerate a vast variety of physical conditions. Most bacterial species are *mesophiles* – this is especially true of pathogenic bacteria growing in the human body, over a temperature range of 35°C - 42°C. Hence, the microbiology laboratory incubator is set at 37°C.

However, certain mesophiles also grow well in food refrigerated at 5°C for long periods – common examples include *Staphylococci* and *Campylobacter* responsible for food poisoning. Lastly, *thermophiles* (also referred to as *extremophiles*) thrive in waste dumps and hot springs, tolerating temperatures of up to 122°C, and are important contaminants in dairy products because they survive pasteurisation temperatures.

The Morning Glory hot spring in Yellowstone National Park. The vivid blue colour is from Cyanobacteria which thrive in its very hot waters.

THE IMPACT OF pH ON BACTERIA



The pH notation is a measurement of hydrogen ion (H+) concentration, and is measured on a logarithmic scale in the range of 0–14. A pH value of 7 represents neutral, a pH below 7 is acidic (representing a higher hydrogen concentration), and a pH above 7 is termed alkaline and represents a lower hydrogen concentration.

The majority of bacterial species grow best under neutral (pH 7.0) conditions, but some tolerate acidic conditions as low as pH 2.0 and alkaline conditions as high as pH 9.5.

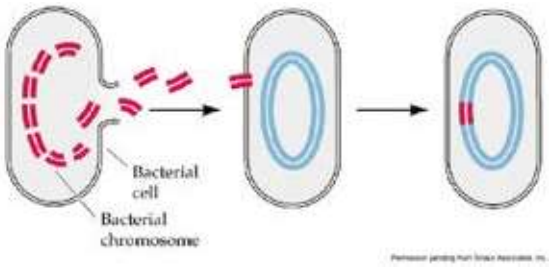
Examples of body sites with an acidic pH include the stomach and the vagina, whereas the pH in the terminal ileum ranges from pH 7.0 – 8.0.

Clinical relevance? The pH of chronic wounds is an important factor for healing. *It has been proven that the surface pH of a wound plays an important role in wound healing, as it helps to control infection and increase antimicrobial activity, oxygen release, angiogenesis and protease activity, while reducing the local toxic effects of bacterial end products*. It has also been observed that wounds with a high alkaline pH have a lower healing rate compared to wounds with a pH closer to neutral.

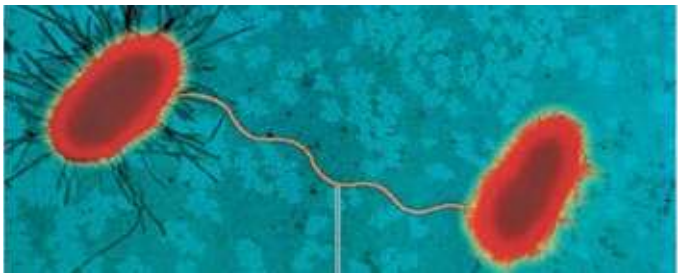
Colonisation and infection with faecal species of bacteria (e.g., Enterococci, E. coli, Proteus and Pseudomonas species) raise wound pH to alkaline levels as a result of their metabolic by-products (e.g., ammonia). The presence of devitalized tissue may further predispose to a high bacterial density, including the presence of anaerobes. This should be remembered when managing wounds adjacent to faecal fistulae, gastrointestinal (GIT) stomas and jejunostomy feeding tubes. This also explains the rationale for using acetic acid or hypochlorous acid for wound cleansing.

Bacterial genetics

Other than natural mutation, bacteria alter their genetic material through a process termed **recombination**. Here, two microorganisms are involved – a 'donor cell' and a 'recipient cell', whereby the donor cell contributes **chromosomal DNA** and/or **plasmid DNA** to the recipient cell. Microbiologists have identified 3 methods for bacterial (genetic) recombination:

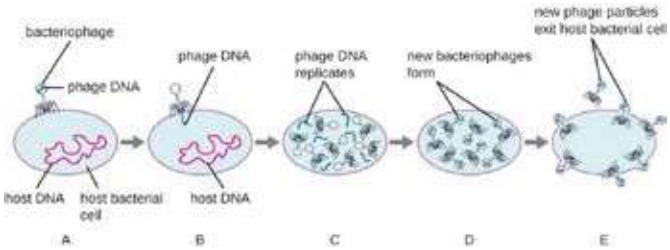


- **Transformation**: Fragments of DNA released from dead, disintegrating bacterial cells are absorbed by living bacteria and the DNA is incorporated into their chromosome – this usually occurs between 2 closely-related species.



- **Conjugation**: Two live bacteria come together, and a special fimbria on the cell wall referred to as a 'sex pilus' extends from one bacterial cell and adheres to another bacterium. At the area of contact, a channel or '*conjugation bridge*' is formed, and a copy of **plasmid DNA** is transferred from the donor to the recipient cell via this channel.

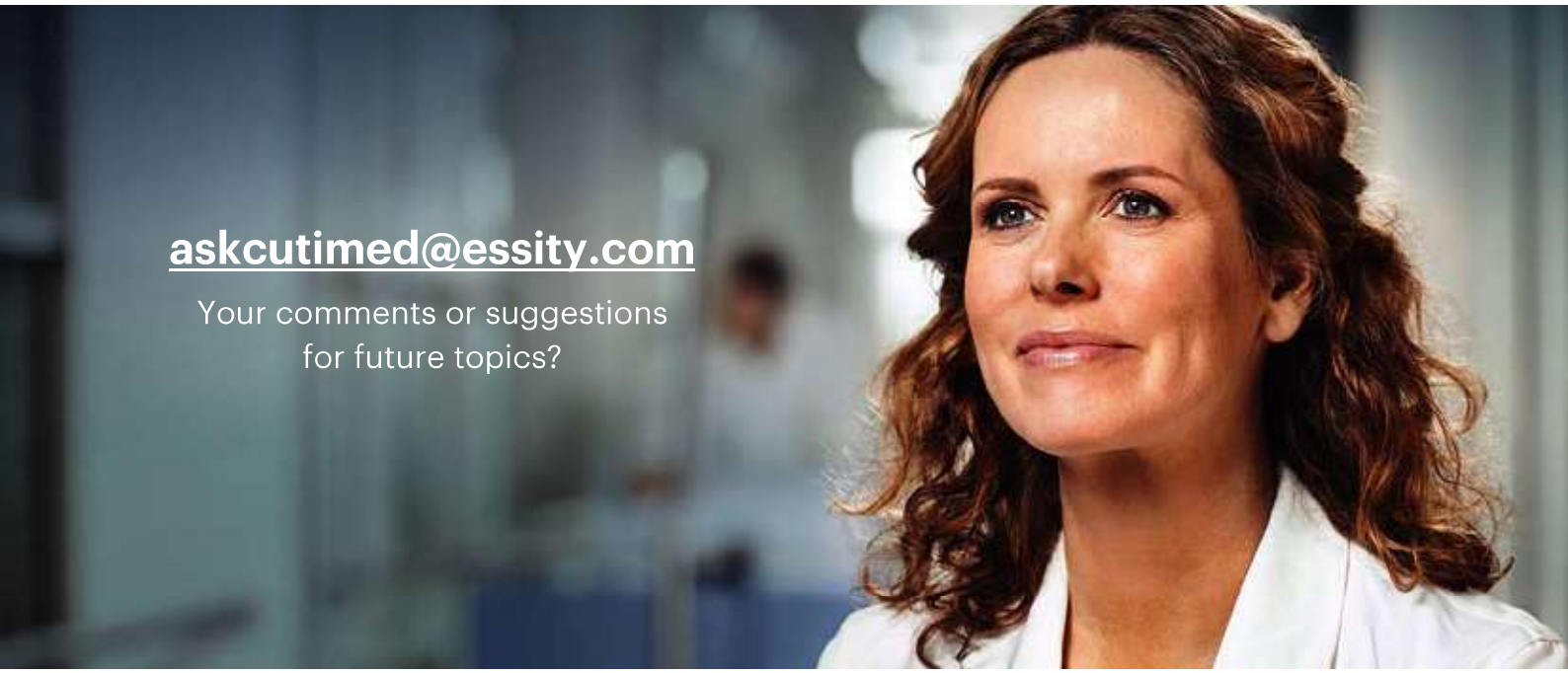
Clinical relevance? Commensal Gram-negative species such E. coli, Serratia, Klebsiella and Pseudomonas species present in the gut are often involved. Sex pili can be formed between like or different species, so this has great significance in the transfer of antibiotic resistance genes via plasmids (e.g., beta lactam and carbapenem resistance). Therefore, species of bacteria which previously had no resistance features will give rise to innumerable generations of bacteria capable of producing antibiotic disabling enzymes known as beta lactamases and *carbapenemases*. *Since these pathogens are spread via contact means, the importance of hand hygiene and thorough cleaning of patient care surfaces and equipment cannot be over-emphasized.*



- **Transduction**: Viruses which infect bacteria are called bacteriophages ('bacteria-eaters'). Bacteriophages attach to and penetrate bacterial cells, copying parts of the host-cell's DNA, which is subsequently replicated in the millions of new bacteriophage copies, which go on to infect other bacteria. Meanwhile, the bacterial host-cell can also acquire resistance genes during replication of the invading bacteriophage - from bacteria the bacteriophage had previously infected!

Lessons learned for infection prevention and control

- Bacteria will thrive under a variety of conditions, particularly where there is moisture available.
- Scrupulous attention to hand hygiene through washing with soap and water and the frequent application of alcohol-based hand rub will prevent the transmission of pathogenic bacteria to vulnerable patients.
- Thorough cleaning of clinical environmental surfaces should be undertaken with a sodium hypochlorite-based detergent disinfectant which demonstrates rapid efficacy against both Gram-positive and Gram-negative bacteria and bacterial spores, leaving a residual effect on the surface.
- Blood, mucous and body fluids should not be permitted to dry out on surfaces, patient care equipment or surgical instruments, because it will not only make them more difficult to clean later, but cleaning is likely to be sub-optimal.
- The pH and oxygen content of the environment will enhance the growth of certain bacterial species, and this is commonly observed in chronic wounds.
- Plasmids are an important cellular component involved in the transfer of antibiotic resistance genes from one species of bacteria to another.
- The development of antibiotic resistance is both a natural and an acquired phenomenon.



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Your comments or suggestions for future topics?

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