

# Bio Factsheet



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## Biology of Colds and Pneumonia

Colds and pneumonia are both respiratory diseases, although the common cold is an upper respiratory tract infection while pneumonia affects the lungs. They are also linked by the fact that there is not one common cause for the infection; they are both caused by a wide variety of pathogens. Both diseases are typically caused by an inflammatory response by the body's immune system. This causes the symptoms of the diseases as a direct result of the inflammation – the chemical processes which are part of this result in increased sensitivity of receptors (pain/tickly coughs/sneezing), increased mucus production (chesty cough/runny nose), and inflammation of passageways (blocked nose/difficulty breathing).

What is the inflammatory response?

- Chemical mediators, including cytokines, are released from a wide range of white blood cells (such as B-lymphocytes, T-lymphocytes, neutrophils, and macrophages) upon recognising an antigen on an invading cell (NB inflammation can be caused in response to a physical trauma).
- These mediators cause:
  - Vasodilation of the blood vessels in the area, increasing blood flow and thus aiding the arrival of white blood cells – this is the redness and heat usually associated with inflammation.
  - Increased permeability of the capillaries, increasing the amount of tissue fluid and allowing certain white blood cells to pass into the tissue fluid – this is the swelling usually associated with inflammation

### Cold

The common cold is a mild viral infection of the upper respiratory tract (nasal cavity, pharynx, and larynx) which can be caused by over 200 different strains of virus. Some of the more common viruses are rhinovirus, coronavirus, human parainfluenza virus, respiratory syncytial virus (RSV), and adenovirus. Symptoms of the disease include a sore throat, blocked or runny nose, sneezing, and coughing. These viruses are airborne, so can spread from person to person via droplets suspended in the air, i.e. if an infected person sneezes or coughs then the virus can be spread to anyone who breathes the particle in. They can also be spread by touching a surface contaminated with the droplets and then touching your mouth or nose.

The virus itself doesn't cause any immediate symptoms; the symptoms of the disease are caused by your own immune response. The exact mechanisms of this response vary depending on the type of virus (see table below), but they all start when a virus attaches to the lining of your upper respiratory tract. As all these viruses are made of RNA, when the viral RNA is present in the membrane, this causes the release of cytokines from the cell, stimulating the inflammatory response. Some of the viruses can cause the lysis of epithelial cells, and the damage to the cells worsens the effect of the sore throat.

Virus	Features	Mechanism of infection
Rhinovirus	Single-stranded RNA virus enclosed in a capsid. 30nm in diameter – small even for viruses.	Virus binds to a cell membrane receptor (either ICAM-1 or CDHR3) & subsequently releases the RNA into the cell to be translated. The cell membrane is disrupted by viral proteins called viroporins, and the virus particles are released when the cell bursts.
Coronavirus	Single-stranded RNA viruses enclosed in a helical capsid and a phospholipid envelope. 120-160nm in diameter.	The virus envelope binds to the membrane and releases the complete viral protein into the cell. Replication occurs within the RER and then the virus particle is released through exocytosis – the cell is weakened but not directly damaged by this process.
Human Parainfluenza Virus	Single-stranded RNA virus enclosed in a capsid and a phospholipid envelope. 150-250nm in diameter.	As with coronavirus.

### Pneumonia

Pneumonia is an inflammation of the alveoli in the lungs and can be caused by bacteria and viruses. Typical symptoms of pneumonia include a productive cough (i.e. coughing up mucus), rapid, shallow breathing, a fever, rapid heart rate, and chest pain.

Bacterial pneumonia is typically contracted through breathing different bacteria into the lungs. *Streptococcus pneumoniae* is the most common cause of bacterial pneumonia but *Haemophilus influenzae*, *Chlamydomphila pneumoniae*, and *Mycoplasma pneumoniae* also cause a significant number of infections. Once the bacteria enter the alveoli, they can move into the spaces between the cells, stimulating the non-specific immune

system to respond. Neutrophils (phagocytic cells) present in the tissue engulf the bacteria and destroy them. As part of this activity, neutrophils release cytokines which cause an inflammatory response to ensure more white blood cells arrive in the infected area.

With viral pneumonia, the many viruses involved are breathed into the lungs via droplets in the air. Some of the common causes of viral pneumonia are rhinoviruses, coronaviruses, influenza virus, respiratory syncytial virus (RSV), adenovirus, and parainfluenza viruses – many of the same causes of the common cold. The only difference is the site of infection, which is the upper respiratory system for the cold and the lungs for pneumonia. Once in the lungs, these viruses will invade the alveolar epithelium and cause the cells to die either through viral-induced cell lysis or through self-destruction (apoptosis). When a cell becomes infected with a virus, the presence of viral RNA molecules and other viral proteins causes the cell to release cytokines. As with bacterial pneumonia and the common cold, this causes the inflammatory response which causes most of the symptoms of the disease.

#### What is phagocytosis?

1. Pseudopodia extend from the cell membrane.
2. They then engulf the pathogen in a vesicle (called a phagosome).
3. Lysosomes fuse with the phagosome.
4. Hydrolytic enzymes within the lysosome hydrolyse the polymers present in the pathogen, destroying it.
5. Acidic pH of lysosome can also denature proteins present.

#### Exam Question

The common cold is a disease of the upper respiratory system and is caused by a wide variety of different viruses. Each of these viruses has a slightly different mechanism of entering the cell it infects but result in the same pathway being activated. The presence of the viral mRNA in the cell causes the cell to produce chemicals which lead to inflammation. This inflammation causes many of the symptoms of a cold.

1. (a) Describe the process of inflammation. (3 marks)
- (b) Different viruses have different proteins present in their capsid. How does this explain why viruses may have a different method of entry to each other? (2 marks)
- (c) Suggest why it is unlikely that a vaccine will be developed for the common cold? (2 marks)

Pneumonia can be caused by some of the same viruses but also by bacteria. This disease affects the lungs rather than the upper respiratory tract but works through the same pathways to cause inflammation. The bacterial mechanisms centre around neutrophils (a type of phagocyte) which respond to the infection and stimulate the inflammatory response.

2. (a) Describe how a phagocyte would act to destroy a bacterium. (4 marks)
- b. Someone with pneumonia often struggles to breathe and can become tired quickly. Suggest how inflammation of the alveoli could lead to these symptoms. (3 marks)

#### Mark Scheme

1. (a) Cytokines/chemokines/interleukin/interferon/chemical mediators released;  
Cause dilation of blood vessels;  
Increases white blood cells in the blood;  
Increases permeability of membranes;  
Increases tissue fluid formation;  
More white blood cells in the tissue fluid.
  - (b) Different proteins have different tertiary structure;  
Bind to different receptors;  
Due to only having a complementary structure to one.
  - (c) Mild disease;  
Lots of different viruses;  
Have different antigens;  
Need a vaccine/memory cell for each virus.
2. (a) Phagocyte recognises foreign antigen;  
Engulfs pathogen;  
Enclosed in vesicle/phagosome;  
Fuses with a lysosome;  
Lysosome contains hydrolytic enzymes;  
Hydrolyses pathogen.
  - (b) Inflammation reduces elasticity of the lungs;  
Less air into lungs/tidal volume decreases;  
Increases diffusion distance;  
Less oxygen diffuses into the blood;  
Less respiration;  
Less ATP produced.

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