**‘Off specification’ examples for the biology essay.**

**General advice**

* **Your priority needs to be writing about 5 decent A-level specification examples. You can still score 23/25 without referring to any off-spec examples. DO NOT NEGLECT THESE TOPICS IN AN ATTEMPT JUST TO INCLUDE AN OFF-SPEC EXAMPLE.**
* **You still need to discuss the off-spec materials at A-level standard; for example - a GCSE description of how emphysema (COPD) affects gas exchange will not be credited.**
* **The example really needs to address the theme of the essay. We have tried to choose examples that could be used in various different essay titles; your job is to pick out the relevant aspect of an example and apply it to the theme.**
1. **Cystic Fibrosis (see old T+T p262-4)**

An example of a genetic disease caused by the deletion of a single amino-acid (three DNA bases – AAA) which results in a non-functioning chloride ion channel, called CFTR (cystic fibrosis trans-membrane-conductance regulator) found in cell membranes. It is an autosomal recessive disorder so 2 healthy heterozygous carrier parents can have an affected child. In people without cystic fibrosis, this ion channel functions normally and performs its role of transporting Cl- ions across cell membranes. The CFTR protein usually transports Cl- out of epithelial cells and therefore water will follow, down a water potential gradient by osmosis. This helps to keep epithelial surfaces moist with thin mucus eg respiratory and digestive surfaces. In people with cystic fibrosis, the CFTR channel does not function normally. Ions are not transported out of cells so less water will follow. This makes surfaces dryer and mucus very thick and sticky. All the symptoms of CF are caused purely as a result of this thicker mucus.

* Mucus congestion in the lungs – increased risk of infections as it provides perfect conditions for bacterial growth and is difficult to remove. This leads to lung scarring and reduced gas exchange. Most people will die from lung complications.
* Accumulation of thick mucus in pancreatic ducts so digestive enzymes, lipases in particular, find it more difficult to reach the duodenum. Absorption of dietary fats is reduced so weight gain can be poor.
* Infertility due to thick mucus blocking sperm ducts and fallopian tubes.

Treatments involve treating infections and trying to thin out secretions.

**Gene therapy is being trialled as a treatment for CF.** Gene replacement (where the defective gene is replaced) or gene supplementation (where copies of the healthy gene are added alongside the defective gene) are two options. The real difficulty in gene therapy is actually in delivering the healthy copy of the gene into the defective epithelial cells AND getting these cells to transcribe and translate this new copy. Even if the gene is successfully inserted into cells, very few are expressed.Vectors used to try and introduce the new copy include harmless viruses such as adenovirus, and wrapping the gene in lipid molecules to form a liposome.

Look at the link below for more info on gene therapy in cf.

<https://www.nhs.uk/news/genetics-and-stem-cells/gene-therapy-breakthrough-for-cystic-fibrosis/>

*You could use this in essays on: cell membranes and cell transport, role of ions, role of water, role of proteins, transfer of genetic material, DNA, mutation and diversity, gene technology ethics.*

1. **Cholera and ORT**

Vibrio *cholera* is the bacterium that causes cholera and is transmitted by drinking dirty water or food that has been contaminated with faecal material containing the bacterium. Symptoms are severe diarrhoea leading to dehydration which can be fatal. If ingested, most Vibrio *cholera* will be killed by the stomach acid, but a few may survive. In the small intestine, remaining bacteria use their flagella to propel themselves through the mucus lining of the intestinal epithelium where they start to produce a toxic protein. This protein binds to complimentary receptors on the epithelial lining (only the small intestine has these receptors so cholera doesn’t affect other sites) and once inside, the toxin makes chloride ion channels in the cell membranes to open, causing a huge loss of chloride ion from the cells into the lumen of the intestine; water follows down a water potential gradient into the lumen causing diarrhoea. Water will continue to move down its water potential gradient from blood to epithelial cell to lumen as long as the toxin is present, causing severe dehydration.

Treatment involves replacing fluids using Oral Rehydration Therapy (ORT). Pure water alone is ineffective because water is not being absorbed from the small intestine in the case of cholera and it does not replace the ions that are also being lost. ORT contains water, sodium ions, glucose and other ions (K+, Cl-). The glucose and Na+ ions can use the still functioning sodium-glucose cotransport proteins and are taken up into the epithelial cells. As the Na ions are absorbed, it starts to lower the water potential of the cells and water from the ORT can now start to be absorbed and replace lost water. The other ions help to restore electrolyte imbalance. The real beauty of ORT is in its simplicity. It is very cheap, can be stored as a dry powder, does not require any real medical expertise to administer so is an ideal treatment in developing countries where access to other means of rehydration is limited.

*You could use this in essays on cell membranes, cell transport, proteins, ions, water, causes and effects of disease, shape (of the toxin binding to receptors to enter cells)*

1. **Conjugation**

Bacteria are able to transfer genetic material to another bacterial cell directly. This is called conjugation or horizontal gene transfer. Vertical gene transfer means how genes are passed from parent to offspring (in mitosis or meiosis). Horizontal gene transfer in humans does not happen but would be like giving your friend some of your genes! Bacteria can do this because their genetic material is not packaged in a nucleus. It relies on plasmids being replicated and then shared with a recipient bacteria as outlined in the diagram below.



With a few bacterial conjugational transfer systems, some transfer can also occur from the recipient strain into the donor strain at the same time. This is known as retrotransfer. The transfer of genetic material can take several minutes or more (up to several hours).

Antibiotic resistance genes are often carried on plasmids. Through conjugation, these resistance genes can be spread horizontally through a population of bacteria and is a major contributor to the current public health crisis arising from the increasing occurrence of antibiotic-resistant pathogenic bacteria. Natural selection occurs and multi-resistant bacteria can evolve and survive more rapidly due to conjugation and horizontal gene transfer. Conjugation may also transfer plasmids that may allow bacteria to use and process new metabolites once again giving them a selective advantage

*You could use this in essays on interactions between organisms, evolution/ variation/natural selection, DNA, transfer of information between cells, causes of disease.*

1. **Chemosynthesis**

The energy fuelling most food chains comes originally from light energy and is transferred to consumers via producers when they photosynthesise. There are various environments that support chemosynthesising bacteria and archaea: most do not receive sunlight ie are in the deep sea. In deep sea vents chemoautotrophs are the primary producer, carrying out chemosynthesis (similar to P/S, but they oxidise eg H2S which gives them the electron needed for reduction of NADP and eventual generation of ATP). Some giant tube worms that live by deep sea volcanic vents contain symbiotic chemosynthetic bacteria which fix carbon.

Chemosynthesis also happens at ‘whale falls’ very deep in the sea (following a succession of other animal communities consuming the flesh): the lipid in whale bones are decayed, releasing H2S which chemosynthetic bacteria can use (same way). It is likely that life evolved from chemosynthesising organisms.

*You could use this in essays on energy flow, photosynthesis, cycles, interactions between organisms and many other ecological topics eg succession (whale carcass), evolution/ variation/natural selection*

1. **HeLa cells**

HeLa cells are a cell culture line that came originally from the cervical cancer of a lady called Henrietta Lack. Up till then (1950’s) it had proven very difficult to culture human cells in a petri dish (to test drugs on, etc). Her cells survived and are still used today (and were used to develop, amongst many other things, polio vaccine). The reason they survived so successfully was because they are able to produce a lot of telomerase. Normally, each time a cell divides, it loses a little bit of the end of each chromosome, called a telomere. Eventually, the cell is unable to divide any more, and dies. Telomerase repairs the telomere, making the cell able to undergo more divisions before it dies.

HeLa cells have been grown for decades in labs around the world. The different cell lines have evolved to be quite different from each other, and from the original cells. One reason for this is that some have undergone ‘chromosome shattering’. This is where the chromosome breaks into several pieces, and then rejoins in a different order.

*You could use this in essays on: variation and genetic diversity, change, evolution, regulation (in this case cell division), cycles, biotech, enzymes, nucleic acids,*

1. **CRISPR Cas9 (made simple!)**

CRISPR Cas9 is a DNA-enzyme complex. (CRISPR is DNA, Cas9 is an enzyme that can cut DNA). It is the ‘immune system’ that bacteria (and archaea) use against viruses. When a virus injects its DNA into a bacterium, the CRIPSR captures a section of the DNA, and puts it into its own sequence. Then an RNA copy is transcribed. This is then attached to a Cas9 enzyme. It can then go and attach to another piece of the same virus DNA (because it is complementary), and the enzyme used to snip the virus DNA up. CRISPR has huge potential for us to use for ‘gene editing’. Biologists are starting to successfully use it, for example, to cut out a faulty gene and replace it with the correct gene. This may replace gene therapy (currently not as successful as we thought it might be) in future treatment of eg cystic fibrosis. *You could use this in essays on: shape, enzymes, nitrogen containing compounds, C containing compounds, biotech, interactions (immunity), nucleic acids, response, evolution/ natural selection, variation, adaptation*