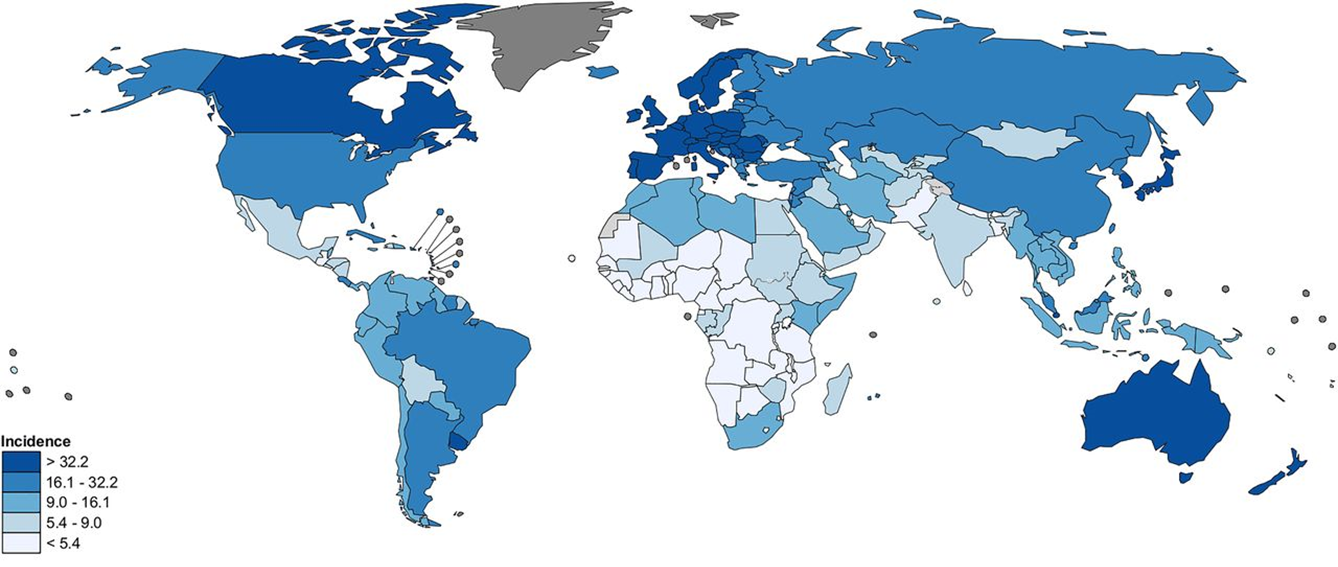
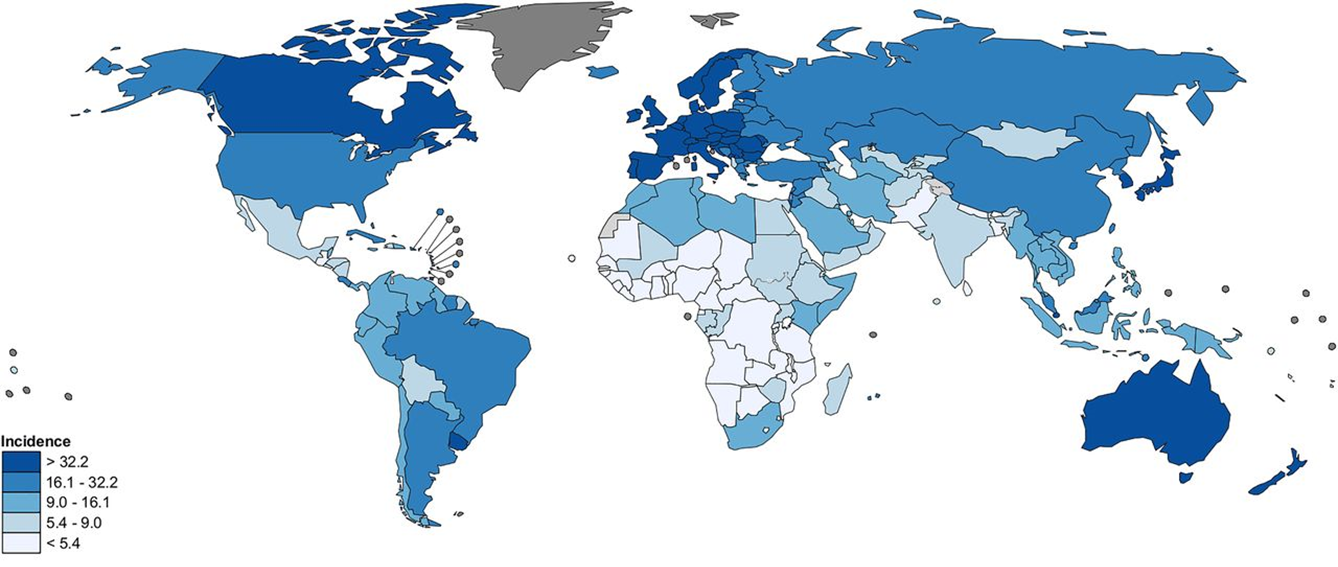
**Biopolymers to prevent cancer**

Colorectal (bowel) cancer is the third most common cancer in men and women worldwide. Recent scientific research suggests that excess iron in the large intestine can lead to the formation of tumours.

Iron is essential in our diet and many of the processes carried out by are cells are catalysed by iron. For example, red blood cells contain haemoglobin, an iron-containing protein responsible for transporting oxygen around the body.

Diets rich in red meat can lead to excess iron in the gut. Almost 55% of bowel cancer cases occur in the more developed regions of the world. Eating too much red meat is an example of a lifestyle risk factor.

This world map shows rates of bowel cancer, per 100000 males, for each country.



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Scientists in Birmingham are using a polymer from seaweed to bind to iron in the intestine. This method works because the seaweed polymer forms a **gel** when it’s mixed with iron. It is hoped that this could help to prevent bowel cancer

**Alginate**

Lots of living creatures make polymers. These are often called biopolymers.

The bones in our bodies contain a biopolymer called collagen. The long collagen molecules twist together to form fibres that give our bones strength and flexibility. Other biopolymers include chitin (from crustacean shells) and cellulose (in plants).

Biopolymers can be extracted from living creatures. We use these extracted biopolymers in our everyday lives, *e.g.* as thickeners in foods.

Seaweed contains a biopolymer called alginate. Alginate is a copolymer, which means it is a polymer made of two types of monomer. The two monomers are guluronate (G) and mannuronate (M) and they are isomers.

The amount of ‘G’ and ‘M’ in alginate depends on which species of seaweed that it’s been extracted from! This is why different seaweeds feel different.

Seaweeds that are rich in guluronate (G) bind very strongly to metal ions such as Ca2+. The positive ions bind strongly to the negative carboxylate groups. Poly-guluronate sections are particularly good at this and they form structures a bit like a cage around the metal ions. The metal ion crosslinks different alginate chains together, forming a gel.

We need calcium in our diet *e.g.* for our bones. So we need an alginate that will bind to Fe3+ ions but leave the Ca2+ ions alone.



**Aim**

To investigate two different alginates to see whether one is better at binding to Fe3+, while leaving Ca2+ alone.

**Method**

Start with the high-G alginate (green). Use a pipette to drop some of the alginate into a solution of iron chloride. Then try calcium chloride. What happens to the drops? Now try the same experiment with high-M alginate (red). Record your observations.



Pipette

Alginate solution

Metal chloride solution

**Results**

|  |  |  |
| --- | --- | --- |
|  | High-G alginate (green) | High-M alginate (red) |
| Iron chloride solution | Jelly beads | Jelly beads |
| Calcium chloride solution | Jelly beads | Dissolves/spreads out |

**Conclusions**

Did you notice any difference between the alginates with iron? How about with calcium? Was one alginate better at forming gels with calcium?

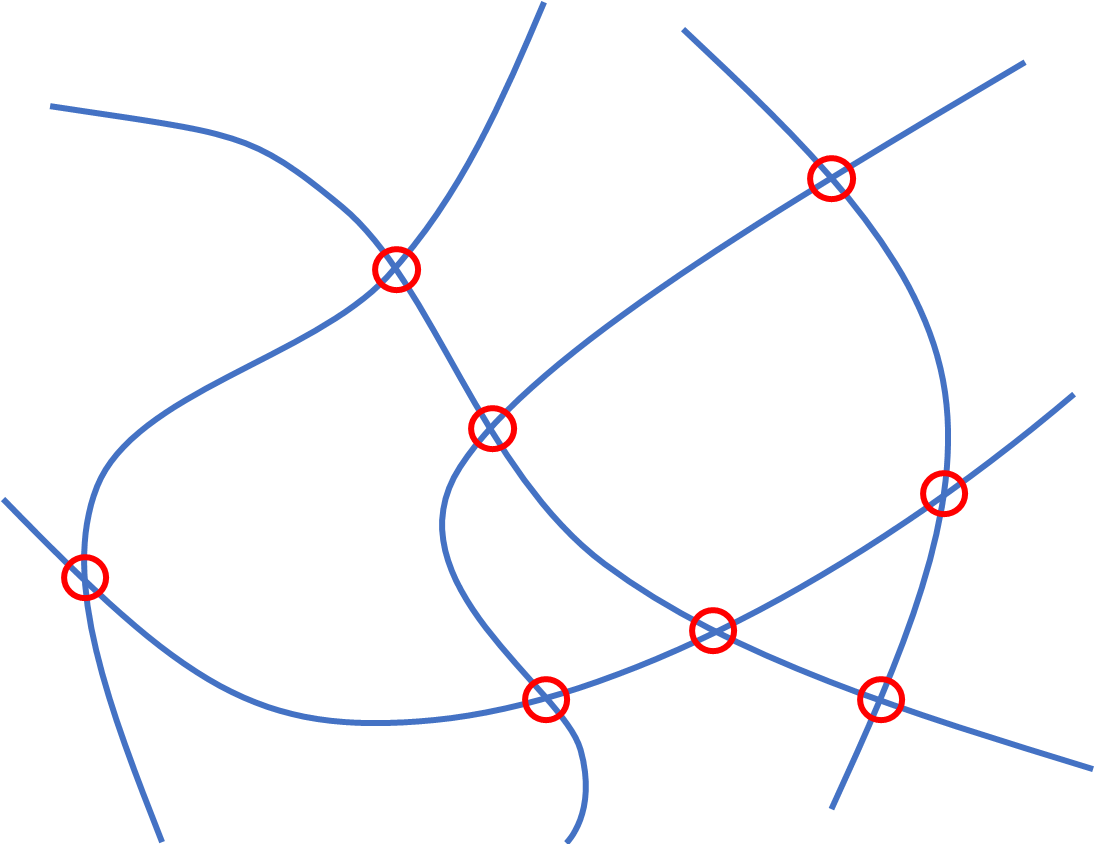
The M alginate forms a gel with iron but not calcium. The G alginate forms gel beads with iron and calcium

If you wanted to use an alginate to bind iron in the bowel but leave calcium alone, which one would you choose? Why? **Note**: the formation of a gel indicates that the polymer is ‘binding’ to the metal, so it’s no longer freely floating around in solution.

The formation of a gel indicates that the metal (iron or calcium) is ‘binding’ to the alginate polymer. The M alginate ‘binds’ to iron but not to calcium. The calcium is then free to be used by the body but the damaging iron is removed.

**How does alginate work?**

Polymers make **gels** in different ways. Gels work by trapping water molecules. Use pieces of string to make a ‘gel’ structure. Tie the strings together where they cross using cable ties. Sketch your gel:



In alginate, the metals are like the cable ties. The metal cation crosslinks negative carboxylate ions on different polymers. The water molecules get trapped in the network and can’t move.

**Topics for further discussion**

* *How might the fact that alginate is a natural product be a disadvantage?*

A challenge with this area of research has been finding funding. Alginate is a natural product, it comes from seaweed. This means it can’t be patented! Given the costs involved in bringing a new medicine to market, a company needs to be sure they are going to make a profit. Without patent protection this may be challenging.

Students have often heard the concept of trademarks or copyright.

* *How could you ensure the alginate gets to the right place in the body?*

Another challenge is how to get alginate to the lower intestine. One area of research on this relies on the changing pH through the digestive tract. It might be possible to encase the alginate in protective layers that are removed as they pass through the different environments of the digestive tract.

* *What advantages might there be of alginate being a natural product?*

An advantage of alginate is that it is already used widely in food as a thickener. It is also applied in some medical applications so it is known to be very safe. It is also likely to have fewer problems with social acceptance given that it is not a synthetic drug, but a natural product.