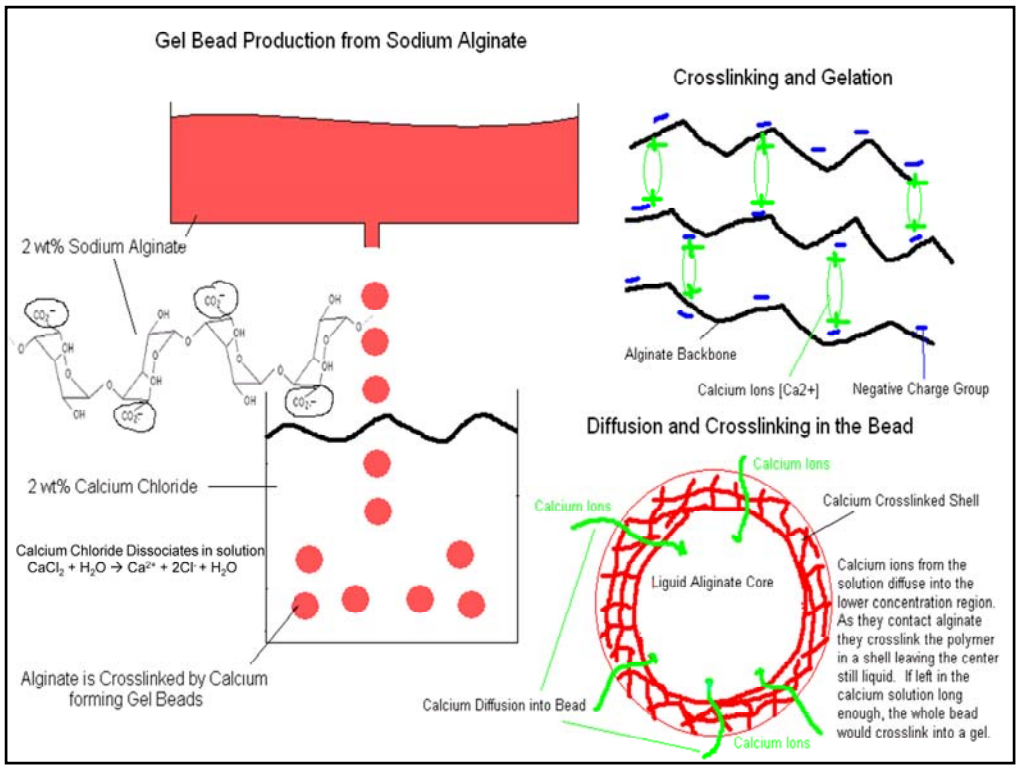


-**Sodium Alginate** is a food grade polymer often used as a thickener, or more technically, a viscosifier (increases viscosity) in products such as fast food franchise shakes, puddings, drinks, salad dressings, etc.

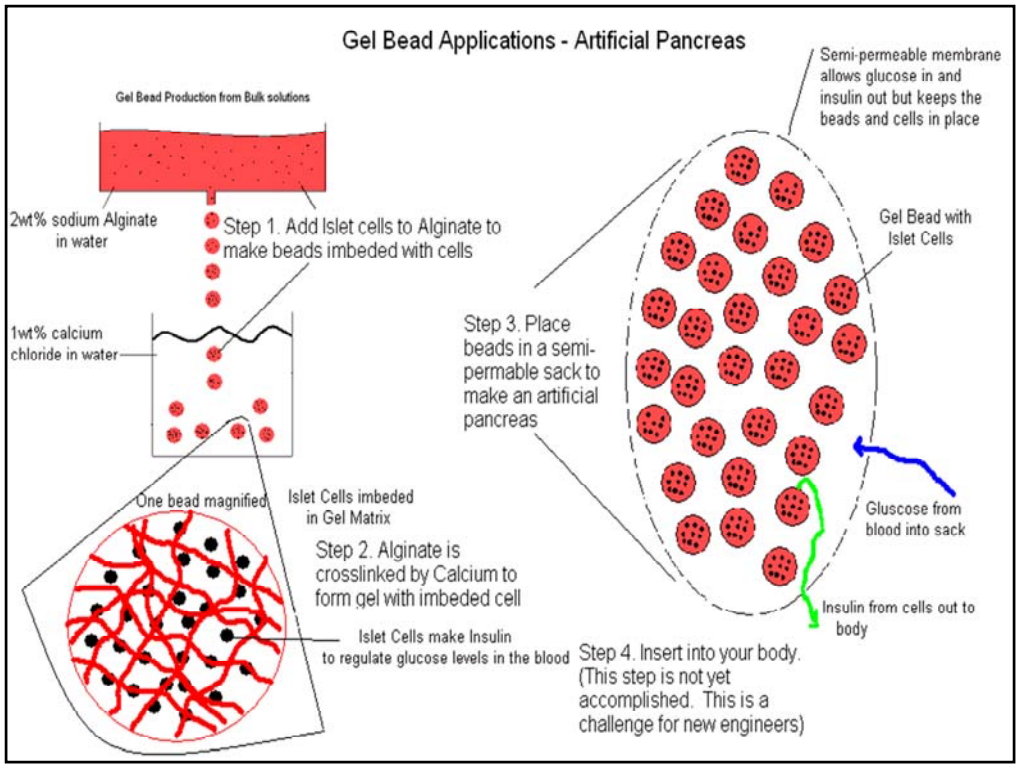
-Sodium Alginate is extracted from giant kelp (a rapidly growing ocean weed), which is harvested in such areas as the Pacific Ocean off the coast of California.

-A **gel** is formed when the polymer chains are tied together (crosslinked). Imagine a 3-D spider web with water in all the empty space. Remember, the **gel beads are 98% water**! A gel has qualities of both solid and a liquid. Jell-O is one gel with which you are probably familiar, formed by heating the polymer gelatin to denature it and then cooling it to reform as a tangled network with hydrogen bonding. Sodium Alginate is chemically crosslinked using a calcium ion (see Figure Crosslinking and Gelation). Both Jell-O and the gel beads made here are in a special class of materials called ***hydrogels***, which are used extensively in the medical field for drug delivery, gel patches with medication embedded within them to be released upon contact with a wound, dressings for burn victims, artificial skin, etc.

How to make gel beads.

Making gel beads is a very simple process. It is as easy as dropping a 2 wt% Sodium Alginate solution into a 1 wt% Calcium Chloride solution. Beads are formed because drops are round and crosslinking begins once the Sodium Alginate hits the calcium chloride solution.

Diffusion is the process of the small molecules (such as the calcium ions) moving through the gel bead and slowly making their way to the center (imagine a colored dye diffusing through water). As the calcium reaches a sodium alginate molecule with an open negative site, it reacts there and makes a crosslink. This process continues until the liquid alginate core (uncrosslinked) becomes completely gelled and the bead becomes semi-solid (like your Jell-O).



ENGINEERING APPLICATIONS

Biomedical Engineering

Design of an Artificial Pancreas

•Insulin is produced in the Pancreas by cells called *Islets of Langerhans* (islet cells) which produce insulin in response to a glucose stimulus.

-Using our gel bead production technique, if we mix islet cells in the sodium alginate solution (see above) they will become **encapsulated** in the gel beads. If we then incorporate hundreds of thousands of these cell-ladden gel beads into a semi-permeable sac, which could then be implanted in the body (and hooked-up by surgeons), we would have an **artificial pancreas**.

-Alternatively, we could build an external device with the sac of gel beads through which the blood could be circulated continuously (such as is done with kidney dialysis right now) as an another form of an artificial pancreas. This allows for easy replacement of the gel beads as islet cells die off or become inactive for some reason. This technology is currently being investigated in research labs around the world.

Bioprocess Engineering (also Chemical Engineering)

Design of a Bioreactor to Produce High Value Pharmaceuticals

•If in the example above, the islet cells are replaced by algae cells harvested off the coat of Oregon that are known to produce a high value pharmaceutical product, we can **encapsulate these algae cells** in the same way.

•These gel beads with algae can be placed into an **air-lift bioreactor** -- basically a vessel filled with growth media for the algae cells which is circulated by bubbling a gas through the solution (like in a fish tank), and which is usually clear so that light can be supplied to the growing algae.

•The algae grow rapidly, producing large quantities of the high value product, which is usually expelled into the outside liquid. After some time, this liquid is removed and the product is recovered by any number of extractive techniques, such as high pressure liquid chromatography (HPLC). In this way, the algae are stimulated to grow fast and produce much more recoverable product then would be possible by ocean harvesting techniques.

Environmental Engineering (also Chemical Engineering)

Clean-Up Of Contaminated Water

•One amazing feature of the gel beads is that they "suck-up" a larger number of toxic materials, such as heavy metals and other pollutants.

•A **packed-bed reacter** (beads packed into a vessel) or a **fluidized bed reactor** (essentially a bunch of beads in a vessel which are kept suspended by a liquid or gas flow through the vessel) can be used to clean-up many types of wastewater streams.

Examples

•A gel bead fluidized bed is being investigated for clean-up of water on the NASA Space Station to enable water recycling (there isn't much water out there in space!).

•An underground water supply (aquifer) that has been contaminated with heavy metal or nuclear wastes (think about the Hanford Nuclear site in the Richland, WA area) can be cleaned by passing the water through a gel bead packed or fluidized bed. The beads remove the contaminants, and when they have reached capacity, the gel beads are removed and dehydrated (remember they are only 2% solid when they are made), which leads to a much smaller amount for solid waste disposal. The process is extremely efficient because the water can simply be pumped from the contaminated aquifer, and either sent to a holding tank for processing as drinking or irrigation water, or simply placed back into the ground.

The *ORBITZ Drink* – a blast from the past!

The Oregonian (1997) – "The spheres float because the have the same ***specific gravity*** as the surrounding liquid"

$$SpecificGravity \equiv \frac{Density_{solution}}{Density_{water\ @\ 4°C}}$$

Don't believe everything you read!

INGREDIENTS: **Water**, High Fructose **Corn Syrup**, Sugar, Sodium Citrate, Citric Acid, Natural Flavor, **Gellan Gum**, **Xanthan Gum**, color added

The **ORBITZ DRINK** has not been produced since about 1996.

Why? Because very few people really enjoyed it (or bought it) in the US. It was a bigger hit overseas.

Question: Why do those little gel beads stay suspended in the liquid?

Wrong Answer: The gel beads are the same density as the surrounding liquid (technical term: neutrally buoyant).

If you could do a few experiments, and were very observant, you could get to the right answer. But since it is no longer available, we'll tell you!

Right Answer: The liquid portion of the drink contains both *xanthan gum* and *gellan gum*, two large polymer molecules (very similar to ***sodium alginate***) that act synergistically (together) to produce a "weak gel network", which gives the liquid a *yield stress* (like ketchup, paint, and many other liquids). This weak gel network suspends the gel beads. It can be easily broken upon pouring, but it reforms quickly when the drink is placed at rest. This weak network breaking and reforming is what gives the Orbitz Drink it's amazing properties to suspend the gel beads at rest but let them move with the liquid when poured or shaken. Check it out for yourself….if you ever see this drink again!

You can always find some of them on eBay!