Issue 4

The Sutton Grammar School Biology Magazine

Matrix Reloaded

Doctors use ground breaking new techniques in an attempt to regenerate human tissue

By Chris Manville

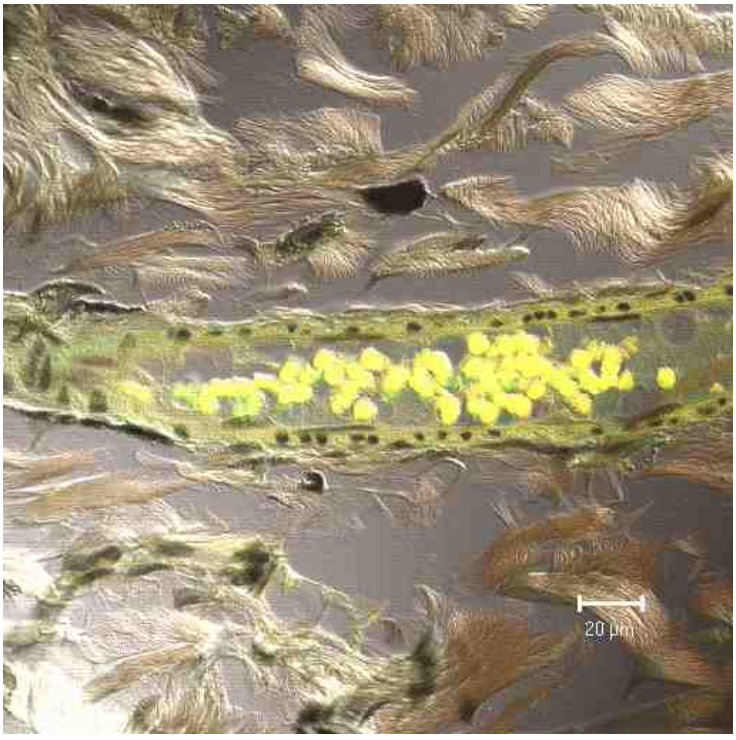
"That a single substance can be used to treat such different conditions reflects matrix's capacity to adapt to its environment."

Normally when we cut or injure ourselves, the body heals itself and leaves scar tissue in its place. Scars are areas of fibrous tissue that replace normal skin (or other tissue) after damage. Scarring is a natural part of the healing process and with the exception of very minor lesions; every wound results in some degree of scarring. Scientists are on the verge of not only preventing scars from forming after injury, but using the same theory to regenerate whole parts of the body.

Five soldiers based in Texas are to take part in an experiment in which they will try to re-grow parts of their fingers or toes. Doctors plan to treat the five soldiers with a fine powder of extracellular matrix extracted from pig bladders. If the experiment is a success it will revolutionise medicine forever. There may be the possibility of curing many deadly diseases and not only surviving major accidents but making a full recovery. This is very small scale at the moment but has the potential to be significantly improved with the sites set on the regeneration of full limbs, including bones and joints and total organ regeneration.

What is the 'extracellular matrix'? I hear you ask. The extracellular matrix (ECM) is found in all animals and has been shown to promote skin and tissue growth on small wounds. For example, salamanders can re-grow their whole leg if it has been cut off, deer shed their antlers every year and re-grow a new set and starfish can also re-grow their arms. ECM is the material found surrounding the cells. In some organisms it is thought that this material is more abundant than the actual cells themselves. ECM contains a vast number of important substances, for example: glycoprotein, collagens, proteins, blood plasma, fibrin and elastin. Due to this diversity, it can serve many functions: providing support and anchorage for cells; providing a way of separating the tissues; regulating intercellular communication; and assisting in the repair of tissues.

In the 1980s, a very important breakthrough took place with Dr. Badylak saving his own life by taking advantage of the ECM properties. Badylak had a severely damaged aorta (the most important artery in the body), so he extracted a portion of a dog's intestine, which is rich in ECM to build himself a makeshift aorta. After the two procedures not only was the dog wagging his tail with part of his digestive system missing, but the 'new' aorta had fully healed leaving minimal scar tissue. The implanted intestine had morphed into a blood vessel with an extremely similar structure to that of a healthy aorta. It is believed that the intestine had somehow sensed whereabouts it was in the body and adapted itself for its new function. Furthermore, the ECM is said to be responsible for this virtually perfect regeneration of the tissues leaving no scars.



Blood vessel (blood cells, yellow) in an extra-cellular matrix

Scientists believe that the human body will have the capability to regenerate or re-grow injured or lost limbs in the near future. This is because this fascinating substance is found in humans. The sub-mucosa, an inner layer of the intestines, contains ECM and when the matrix material breaks down, healthy living tissue, not scar tissue, replaces it.

The future doesn't seem so far away!

Inside This Issue of Life.

The Maths of Biology

Fibonacci and his sequence

By Nick Pepper

The majority of readers who have read or watched the Da Vinci code will remember the famous sequence that is integral to the story. Fewer will know of the sequence's original purpose and what the sequence was designed to do.

Fibonacci had travelled around Italy until about 1200, at which time he returned to Pisa, the city which his father had represented as ambassador in North Africa. In Pisa, Fibonacci made his first valuable contributions to mathematics. It was in the third section of his famous work the *'Liber Abacci'*, written in 1202, that the sequence first appeared. In this book Fibonacci was trying to answer several questions relating to mathematics and the world that he had seen during his travels. These included problems like:

- The time taken for a greyhound to catch a hare if both of their speeds increase arithmetically.
- The time taken for a spider to climb a wall if it falls each day at a certain value.

Fibonacci had been fascinated by the golden ratio. This is an irrational number that expresses the relationship between two quantities. A common example is the arrangement of seeds in a sunflower plant. He tried to find a sequence that could define the golden ratio; this could then provide him and other mathematicians with a greater understanding of mathematics in nature.

To this end, he constructed a question involving the number of litters that a group of rabbits would give birth to and set about solving it. The resulting sequence was:

1. The mother gives birth to 1 litter

1. The new litter is still not developed

2. The new litter and the original mother (assumed to not die) give birth.

3. All three mothers then give birth

This forms the beginning of the Fibonacci sequence.

However, this sequence still affects our lives today in the form of mathematical biology. This is a seldom known branch of biology that draws its ideas from the Fibonacci Sequence, written 800 years ago. This form of mathematics has evolved to replicate processes that occur in the body, such as respiration as well as processes in the outside world as Fibonacci did.

This is a major leap forward in science into investigating the seemingly irrational factors that affect organisms. Firstly, biologists take a model of what they want to factorise, such as a model strand of DNA and using sequence analysis, reduce it to basic equations. Once analysed into sequences, the equations allow scientists to study molecular patterns that are incredibly complex.

The main use of mathematical biology is in population dynamics, the study of the long term and short term effects on population and the factors that affect them. This helps us understand the nature of seemingly illogical behaviour and if it is at all influenced chemically. Another well known use of mathematical biology is in the deciphering of DNA strands, allowing further progress in the genome project.

Bird Flu Panic

H5N1 Bird Flu Virus

By Sam Gardner

Although it is now starting to lapse into history, the recent outbreak of Bird Flu at Bernard Matthews' turkey farm in Holton, Suffolk remains worthy of note, to some considerable extent.

159,000 turkeys died there, although how many of these died of H5N1 and how many died of Carbon Dioxide Poisoning is unclear.

What is certain is that the whole incident received a great deal of media attention. Whether this is really necessary though is a matter that remains far from certain.

There are approximately 30,000,000 chickens in the UK that are used to lay eggs, and approximately 800,000,000 that are slaughtered for food each year. This means that the Holton outbreak killed approximately 0.00009% of all the domesticated poultry in the United Kingdom. And this was mainly culling of the turkeys, rather than them actually dying of Bird Flu (only three units were contaminated, but the entire farm was culled).

However, this incident cannot be taken lightly. This Bird Flu had to come from somewhere. There are two possibilities down this road. One is that it came from a bird imported from Hungary. This seems unlikely though, as Bird Flu has not been rampaging through Hungarian Poultry (at least, not in the timescale required for this hypothesis to be correct). The other, more insidious possibility is that it came from a wild bird in the UK, a prospect that many people, quite rightly, find worrying. It means that somewhere out there are possibly wild birds with Bird Flu, beyond the extent of one dead Swan in Fife.

It isn't difficult to see why people are concerned about Bird Flu in the UK. It kills slightly more than half of humans who present with severe symptoms of the disease due to extreme lung damage (Cytokines produced to combat the infection destroy vital tissues, resulting in difficulty breathing and eventual drowning as blood fills the lungs) or major systemic failure (organs not working due to damage inflicted by the virus itself). In poultry, it is even more dangerous with virtually all infected birds dying of major systemic failure.

Don't panic yet! It was a pretty small outbreak in the grand scale of things, and the current strain of H5N1 is so poor at transmitting itself that you could eat an infected bird raw and (probably) not fall ill.

The Enzyme of Eternal Youth?

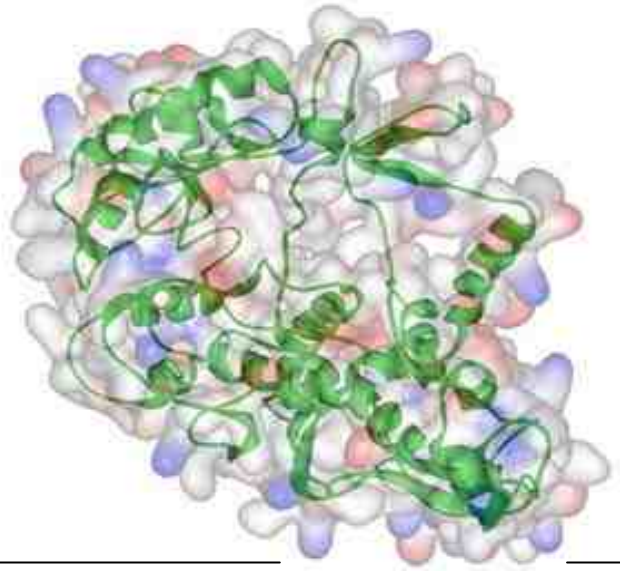
By Carl Alexander

Two years ago a pharmacology researcher called Vimal Kapoor was inspired after reading an article about a newly discovered enzyme. The researchers had identified this enzyme as Pre-B-cell colony Enhancing Factor or PBEF, but they had not worked out what its exact role in the body was. However, this caught Kapoor's attention and he believed that this enzyme could be the missing link in chemical ageing of the body.

The reason we age is because many cells in the body reach the end of their lives, and disassemble themselves in a process called apoptosis. When cells die in major organs, such as the heart and lungs of elderly people, it makes them physically weaker and more susceptible to illness and disease. Young and healthy cells produce a chemical called NAD, which provides cells with energy so that they can make new chemicals. It is thought that the newly discovered enzyme: PBEF plays a key part in recycling NAD within cells. If cells were to be implanted with more PBEF, it would be like giving them more energy and therefore slowing down the process of ageing.

Kapoor's research team have now been able to produce crystals of the enzyme and will be able to determine its 3D structure using a technique called x-ray crystallography. They also believe that a drug can be developed to block the production of PBEF in cancer cells, preventing the further growth of cancer.

Unfortunately it seems that they will not be able use the enzyme to extend life without raising some serious ethical issues. For example, the only way to currently deliver PBEF to all cells in the human body would be to genetically modify a person's egg cell before it grows into a foetus. There is a possibility that other ways will be found to deliver this enzyme, but it is believed that this could take over 10 years and even then, it will still be almost impossible to overcome.

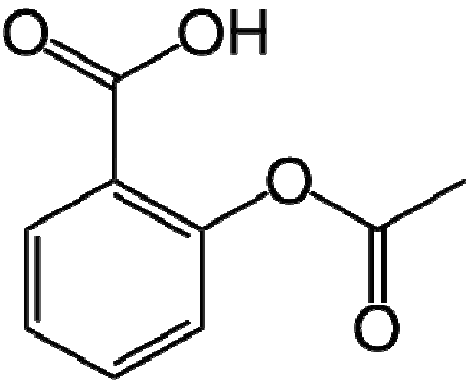


Predicted 3D structure of the PBEF enzyme

On the other hand, it seems more possible that we could use PBEF blockers to initiate apoptosis in cancer cells, thus killing them. In contrast, we could use increased levels of PBEF to prevent conditions that result from excessive cell-death, such as Alzheimer's disease, which is caused by apoptosis of the brain cells. Otherwise, it can be used to treat people with diabetes, where insulin producing cells have died out.

Although it seems that eternal youth is a long way off, it does seem that there is a possibility that this newly discovered enzyme could be used to extend the lives of those who need it most.

Molecule of the Fortnight - Aspirin



By Richard Morris

Aspirin ($C_9H_8O_4$) is a well-known and widely used drug that was first patented in 1899. Aspirin is formed from an extract of willow bark: salicylic acid. Salicylic acid had been used as a treatment for minor ailments since at least 400 BC, but has many unpleasant side effects, even in relatively small doses.

Modern aspirin was developed in 1897 when a German chemist discovered a way to alter the natural acid in order to reduce the side effects. This was in fact the first artificially synthesised drug. It has been toasted as "the most effective and versatile medicine". It is true that aspirin is used for treating many different ailments.

The most common use of aspirin used to be for treatment of minor aches and pains, but it has lost popularity in recent years in favour of other painkillers such as paracetamol and ibuprofen. One major use is in preventative treatment of heart attacks and strokes.

Aspirin has a 'blood-thinning' effect; it can reduce the clotting effect of platelets. As detailed in the last issue, many chemicals act as enzyme inhibitors. Aspirin irreversibly inhibits the production of a hormone responsible for major blood clotting. Thus, it can be used to prevent the build-up of blood clots in the brain and heart and in turn reduce the risk of heart attacks and strokes. However, it can also lead to massive blood loss from injury, because the blood does not clot to seal the wound.

Overdoses of aspirin can cause intestinal bleeding, coma and death. If an overdose is taken, hospital treatment should be sought immediately.

Aspirin has also been found to have beneficial effects on some cancers, although it was recently ruled that its use against colon cancer is "too risky". If enough is taken to affect the cancer, it can have dangerous side effects.

Aspirin is one of the most well-known and widely used drugs, and its synthesis heralded the beginning of the modern pharmaceutical industry.

Conjoined Twins

By Dominic Brown

Ostensibly, it is one of the most macabre corners of biology; two human beings disfiguringly fused and often sharing vital organs. It is also thankfully uncommon; only occurring in one in every several hundred thousand live births. This may seem quite odd as the circumstances that engender conjoined twins appear rather ordinary. Firstly, two identical nuclei have to present in the fertilized zygote, as with conventional identical twins. Usually, the zygote would then split so two separate embryos can embed in the womb. This does not happen with conjoined twins and is the reason for their predicament.

Conjoined twins are often known as 'Siamese', referring to the famous Thai (Siamese at the time) pair that toured North America in the 19th century (right); they were joined at the sternum. Fusing may occur in many parts of the body. While babies joined at the hip usually do not experience major difficulties (aside from the obvious impracticalities), those sharing vital organs, especially the brain, rarely survive or only do so with medical assistance. Many are born with prospects of a severely impaired quality of life. This opens the Pandora's Box of the 'right to life' discussion. In a large number of such cases, if one of the twins is terminated, the other has a much greater chance of survival. If the children are left alone, it is often likely that both will die. Whether we 'interfere' or 'let nature take its course' is a matter of vehement debate and was highlighted in the year 2000 when the High

Court ordered surgeons to separate twins against their parents will; it meant that one child had to die for the other to live. As can be the case, the child euthanized was merely a parasite and relied on its sibling for a blood supply. Nonetheless, ethical considerations can in fact be ignored most of the time as half of all pairs of conjoined twins are stillborn, with the remaining 35% surviving less than a week.

Sport Science - Muscle Cramps

Stretching can help to relieve cramp

By George Butcher, Adam Gillis and John Gorringe

What is a cramp?

Cramps are not really an injury but are a common occurrence in many sports and prevent you from playing at your best. They are usually painful and unpleasant sensations caused through contraction or over shortening of muscles. Cramps can be caused by the cold and illness, but poisoning can also cause cramps, especially in the stomach.

How are they caused?

This occurs from the overexertion or dehydration of the specific muscles. When you don't have enough fluid in your system it leads to an electrolyte imbalance and this is what causes your muscles to cramp up. Electrolytes are minerals such as sodium, magnesium, calcium and potassium. Eating foods that are high in these minerals can help prevent cramps.

Another way that you can get cramps is through inactivity, such as sitting too long without moving a muscle or lying in bed. Researchers still haven't found out why this causes your muscles to seize up but are currently researching it.

How are they treated?

We have found out that there are a lot of ways to get cramps, but there are also a lot of ways to get rid of them. Firstly, you can apply a soft massage to the muscle so that you can feel your fingers pressing on the surface. You can also apply heat or cold to the area where you have cramped up. Using heat pads or ice sooths the muscle and helps it to relax.

Of course you can also stretch the muscle as you have probably seen the medical teams do in a football match to the players.

Which muscles are affected?

Hamstrings, Quadriceps, Back of lower calf, Feet, Arms, Abdomen, Along the rib cage

What are the symptoms?

The symptoms of having a cramp are numerous. Often the largest one is the agonising pain that you get coming from the affected area. The muscle may feel hard to touch and make the leg around it feel stiffer than normal, more rigid. A visual distortion can sometimes be seen in the affected area and the muscle can often twitch beneath the skin. The cramp can last a few seconds to more than 15 minutes and may re-occur several times before going away.

Who gets Cramps?

Anybody can get cramps and everyone will experience a muscle cramp sometime in their life. Sometimes the slightest movements can trigger one. However Athletes and elderly people are more prone to cramps:

Athletes are more likely to get cramps in the pre-season when their body is not conditioned and subject to fatigue.

Older people are more susceptible to muscle cramps due to normal muscle loss that accelerates due to inactivity. As you age, your muscles cannot work as hard or as quickly as they used to.

Being a Doctor

Have you got what it takes?

By Kyung Hoon Moon

Five days of work experience at St. George's Hospital was definitely a fascinating experience. Getting up at 6am and having to be registered by 8 o'clock in the morning and coming back home at 7pm was not an unusual daily life for the most of medical workers in St George's. In fact some may work more than that. The daily work is not specifically in a routine form. Most duties are based on two rounds of checking and recording assigned patients' conditions and prescription (about 10 patients a day). Patients come in and out and doctors will often forget trivial conversations staged five seconds ago! The ward I worked in is the Upper GI Surgical firm, where patients who will or have had operations around their lower abdominals are being monitored. The work involves a variety of techniques. They are mainly taking blood, sending for arterial gas checks, monitoring ECG (blood pressure and oxygen supply levels), performing a pre-surgery clinical check-up - asking lists of repetitive questions to different patients repeatedly - attending surgery and performing physical check-ups. I have also realized that doctors are not always doing practical work all the time. They are also obliged to produce documents and forms including request forms for X-rays, ERCP, MRCP, blood analysis and so on. Patient record books must be kept updated during the rounds so that conditions can be analysed. Often patients are on different floors and as elevators are quite slow doctors often run up and down the stairs. The five day experience felt like 5 weeks and I have learnt a lot of intriguing facts about working as a doctor.

Are you unsure about your future career? Then ask yourself, do you want spend your life helping others? Doctors heal people, save lives, and help others often through direct interactions. This must be considered as primary motivation. Do you enjoy working hard? Medicine is an incredibly challenging field. You must have the commitment to contribute effort into lifelong learning. Are you interested in science and health issues? If you enjoyed some aspects of your science courses (few people enjoy all aspects of pre-medical course work) and you find yourself drawn to health issues, there is a good chance that you will enjoy studying and practising medicine.

Working with doctors in a hospital taught me that everyday is new in hospitals. Becoming a doctor requires a real commitment, so the decision to pursue this career path should be an informed one. You should consider information from discussions with medical professionals as well as from websites. However as a keen future medical student and the writer of this article, I hope my words could also influence your perceptions on your medical related future careers.

That's Life.

How much do you know?

By Alex Robinson

1. True or false: a crocodile cannot stick out its tongue?

2. Which animal can jump 350 times its own body length?

3. Which animal's eye is bigger than its brain?

4. How many viruses have scientists discovered?

5. Why do fingers and toes wrinkle in the bathtub?

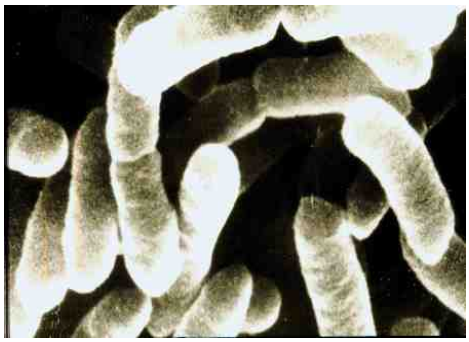
6. True or false: eating an orange can help you see the stars.

7. True or false: there are fewer nerve cells in the human brain than there are stars in the Milky Way.

8. How much water does a camel's hump hold?

9. Where in the body is the highest rate of mitosis?

10. For how long would you have to yell to produce enough heat to heat one cup of coffee?



We have only identified around a tenth of all viruses believed to exist on earth

1. True

2. The flea can jump 350 times its body length

3. An ostrich's eye is bigger than its brain.

4. Scientists have identified only 4,000 different viruses, a fraction of the estimated 400,000 believed to exist on Earth.

5. The outermost layer of the skin swells when it absorbs water. It is tightly attached to the skin underneath, so it compensates for the increased area by wrinkling.

6. True

7. False - there are more nerve cells in the human brain than there are stars in the Milky Way.

8. None. A camel's hump does not hold water at all - it actually stores fat.

9. Hair

10. If you yelled for 8 years, 7 months, and 6 days, you would have produced enough sound energy to heat up one cup of coffee.