Cracking a primordial mystery

A team of scientists has published a paper recently that looks into how amino acids formed on early Earth to birth complex life

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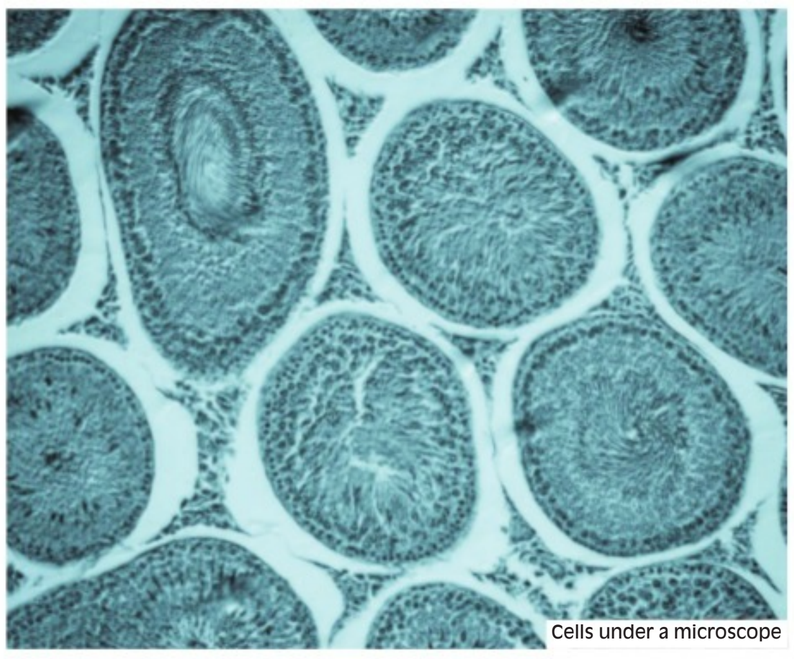
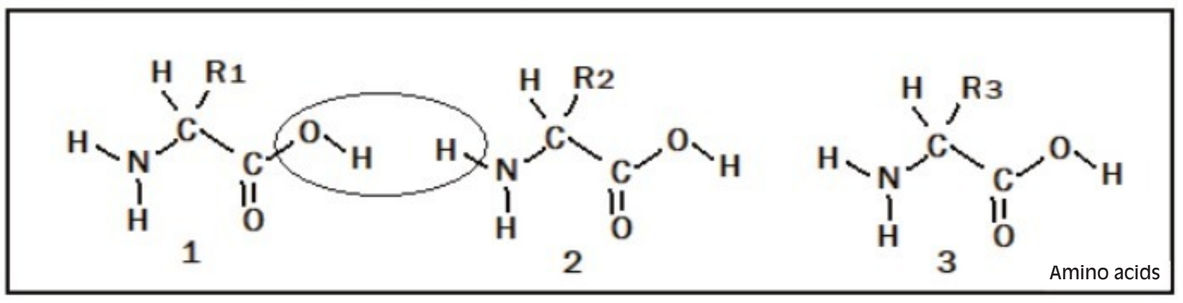

Cells under a microscope


Gregor Mendel



Amino acids

The molecular basis of genetics, reproduction and evolution has enabled scientists to trace our origins back to the earliest of life forms. How the first living thing arose, to reproduce and start the process, however, has been a puzzle.

The puzzle arises because the mechanics of life depend on proteins, the generation of which is the hallmark of life. Proteins, in their millions of forms, are assembled from a base-set of just 20 molecules known as amino acids. Assembling amino acids into proteins, however, consumes energy and depends on catalysts known as enzymes. Now, enzymes are proteins themselves. How then, could these proteins, which we need for protein assembly, have been assembled in the first place? This is the "chicken and egg" problem that has troubled scientists. Pierre Canavelli, Saidul Islam and Matthew W Powner, from University College London, London, report in the journal, *Nature*, that they may have found the answer.

The processes that underlie the evolution of species from earlier life forms unfolded when the mechanisms of reproduction and heredity were understood. A mystery that had long puzzled scientists was how the great variety of species that exist could have come about. One theory, proposed by the naturalist, Jean-Baptiste Lamarck, was of the transmutation of the species — the simplest creatures arose spontaneously and were driven, by a life force that infused them, to increasing complexity. There was also the experience of controlled breeding, which could promote specific traits in domestic animals. There was no indication, however, of what the driver was in the natural world. It was Charles Darwin who realised that it was for of the survival of the fittest that traits were selectively bred among living things in the wild.

The work of Gregor Mendel was followed by discovery that living cells had components that participated in reproduction and heredity. This led to the discovery that the nucleus of every cell contained a chain molecule called DNA, which programmed what proteins the cell would produce. Much of the structure of a cell is made up of proteins and virtually all actions of the cell are triggered by proteins. The proteins a cell produces hence determines what a cell is — a brain cell or a liver cell, and the cell of a human, animal or plant.

The DNA molecule is millions of units long and consists of segments, each of which contain the blueprint for a different protein. As the DNA can also create a duplicate of itself when the cell divides, it is a device that explains both reproduction and heredity. It could hence be conceived that the great diversity of life forms we have could have evolved from the first, rudimentary organism, with a bare bones DNA, which arose out of the soup of chemicals that once covered parts of the Earth.

The trouble with this picture, however, comes into view when we examine how the information in the DNA is made use of to create proteins. Each of the segments in the DNA consists of a series of triplets, or groups of three chemical forms, called "bases", selected out of four possible kinds. These four kinds are known as A, C, G and T, and each triplet has to be made up of bases only from these four.

As each of the three members of the triplet can be any one for four alternatives, we can see the total number possible triplets is 4x4x4=64. Hence, if each triplet is used to identify a particular molecule, 64 different molecules can be identified by the "three character code" formed by one triplet. The 64 codes, however, are used to identify only 20 amino acids, the building blocks of proteins, by providing duplicate codes, to prevent errors, and allow for triplets to mark the "start" and the "end" of a series. And with 20 identified, a chain of triplets can stand for a great variety of sequences or amino acids, and hence for millions of different proteins.

Now for how the code in the DNA results in proteins getting formed. While the DNA is inside the nucleus, the formation of proteins takes place outside the nucleus. The portion of the DNA that codes for a particular protein, as marked by the "start" and "end" triplets, is first copied, in a form that is similar to the DNA, on to a strand called the messenger RNA, or mRNA. When the mRNA is in the outer part of the cell, other functional parts of the cell get active for the specific amino acids to line up, according to the sequence of triplet codes contained in the mRNA. With the amino acids thus arranged, the protein molecule can take form.

The trouble is that it takes energy for the amino acids to pair up, with neighbours, to form a chain. The structure of amino acids, as shown in the picture, is that they all have an "N-H" group at one end and an "O-H" group at the other, the difference is according to the nature of the group, "R". Now, the "H" at the first end of one amino acid can combine with the "O-H" at the other end of the next amino acid, to form a molecule of H2O, or water, which gets released, leaving the two amino acids linked or bonded.

Now, for this energy-consuming reaction that leads to the linking of amino acids to proceed rapidly, there is a need for special molecules that can ease the process. Such catalysts and sites where amino acids need less energy to bond are provided by bodies called ribosomes, with which enzymes and other proteins are associated. Hence the question — how were the first promoters of amino acid bonding created, when their very creation would involve the formation of amino acid bonds?

As the bonding of amino acids consumes energy and releases water, the presence of water can result in the breaking of the bond. The University College authors of the paper in *Nature* note that there is evidence that the first linked amino acid chains came into being before the first living things and played a part in the origin of life. But there is no plausible way these chains could have formed in the watery medium of early Earth.

Rather than look for a way to get amino acids to form bonds while bathed in water, the authors turned their gaze on amino nitriles — compounds that contain less "H" and "O" atoms — and combine with water, giving off energy, to form amino acids. These compounds, which are an earlier form of amino acids, were found to be capable of linking up directly to form the amino acid chain without the intermediate, "combining with water" and then a "giving up the water" phase. The group has found that this reaction took place and the reagents necessary were available during the primitive times when the first life forms appeared.

The team is now studying other ways to form amino acid chains, and the properties of chains that formed in this way, to learn more of how life, which sustains itself, was "bootstrapped" into existence.

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PLUS POINTS

What s your password?

A study has shown that people build their passwords from personal information for a variety of reasons including to invoke important memories or achieve future goals. Surveys conducted by Robbie Taylor, who is completing a PhD in Psychology from Victoria University of Wellington, alongside Professor Maryanne Garry from the University of Waikato, New Zealand, found around half of the respondents infused their passwords with autobiographical memories.

Taylor said there's one obvious explanation for why people infuse their passwords with personal information — because the passwords are easier to remember. He said, "People are trying to reduce the burden of remembering completely random passwords. People are potentially trading off security for ease of remembering.

"The other explanation we found some evidence for is people might want to recall these memories when they type their passwords. That is, people might use passwords like digital mementos. Many people keep meaningful photos and physical mementos around their office at work. Some people may not look at these mementos to remind themselves of the associated memories very often. But, perhaps people with meaningful passwords might think of those associated memories more often because they type their password frequently. It could be a strategy to savour certain memories."

The study was inspired by a 2014 article in the *New York Times*. "The article described the dilemma some companies faced following the September 11 attacks, in which a large number of their employees died," said Taylor, "One financial company needed to access the work files of the deceased, so they rang around asking family members for personal details to potentially find facts that could be in those passwords. The company found this method surprisingly successful.

"It's quite an interesting behaviour and, as we found, it's quite common."

'We are in need of a much-advanced air purifier'

Professor Nabarun Ghosh of West Texas A&M University, United States, delivered a lecture recently at Science City in Kolkata. In a conversation later, he spoke about the effects of air pollution and perils of underage smoking

DEYA BHATTACHARYYA


Nabarun Ghosh


Bacterial growth on the tiles of roofs can worsen air quality inside the room


A file photo of pollution in Delhi

Science City, Kolkata organised a popular science lecture on "Recent Applications of Biotechnology and Biomedical Engineering in improving Air Quality and Medicine". The lecture was delivered by Nabarun Ghosh, professor of biology and advisor for biology education, department of life earth and environmental sciences, West Texas A&M University, Canyon, Texas US. Ghosh delivered a most fascinating speech and after that answered a few questions. Excerpts:

Q You mentioned the presence of aerosols, including particulate matter 2.5, in your enlightening lecture. Could you please elucidate this matter?

Aerosols, including particulate matter 2.5, are the reasons for many allergic reactions and respiratory syndromes. PM 2.5 is present in heavily-polluted areas such as southern Californian cities, New Delhi, China and New York. Based on studies from clinics and hospital admissions, PM 2.5, composed of metals and products from fuel combustion, has been positively correlated with increased cases of allergic rhinitis, asthma, bronchitis, allergic pharyngitis and many other diseases.

Since it has a diameter of only 2.5 micrometres, this particulate matter is often not visible to the human eye. It is inhaled and causes irritation to the lungs. Many big cities in the world contain PM 2.5 in much higher concentrations than the permissible limits.

Q Apart from governments, how can businesses help with combating this?

Global economies are so tightly interconnected that companies, governments and industries will soon be forced to cooperate in ways we could not have imagined just a few years ago. Innovations in technology continue to have massive effects on business and society. We're now seeing emerging markets become hotbeds of innovation, especially in efforts to reach the growing middle class and low-income consumers around the globe. Collaboration between the corporate world and academia has proved to be beneficial in scientific inventions.

Q Do tell us about the new air purifier that has been developed by your team.

With increased population growth and industrial expansion, most cities are experiencing poor air quality. Global warming exerts substantial effects on flora and fauna all over the world. Increasing greenhouse gasses causes accelerated pollinosis and fungal spore production -- two major aero-allergens that trigger asthma and allergy symptoms. We are in need of a much-advanced air purifier that works more efficiently than those in the market.

A decade-long research in aerobiology and nanotechnology helped us develop an air purification system that uses bi-polar ionisation to reduce indoor aero-allergen, improve air quality and aid better food preservation.

The new "Air For Life" air purifiers utilise a new generation of ionisation technology that is more efficient than the conventional air purifiers. This new technology simply produces a blanket of redundant oxidisers that not only clean the surrounding air but also sanitise surfaces.

There is ongoing work at the research and development unit of "Air For Life" (UK) in collaboration with the West Texas A&M University to apply the ionisation technology to develop commodities like air purification systems for homes, hotels and hospital facilities.

Q What actually causes such high concentrations of PM 2.5 in big cities?

The main reason is excessive burning of fossil fuels including gases from industrial exhausts. In our cities in India, the problem increases during winters as the burning of plastic products, tyres and fuel wood causes excessive PM 2.5 accumulation. Burning of crop residues in the neighbouring states of Delhi is causing the air pollution in the capital, which is considered highest among the busiest cities of the world.

Q Why exactly is indoor air quality so bad?

It fully depends upon the aeration system and physical condition of a room. Damp weather can cause production of bacteria and fungi, especially on the tiles of a room. Oil papers could be a dangerous source of microbial growth adding the polluted indoor air. If the air quality outside is poor, more pollutants are added to the room.

Q You also talked about the perils of smoking. What do you have to say about underage smoking?

It is very dangerous, especially during the development of one's organs. All the natural physiological processes are disrupted due to the administration of nicotine from smoking or chewing tobacco, which is classified as a teratogen (causing birth defect), mutagen (causing mutation) and carcinogen (causing cancer).

Such people will have an immune-suppressant condition and suffer from various respiratory diseases in their lives.

Magnified effect

Only 38 per cent of tropical forest can protect wildlife from rising temperatures as a result of deforestation, increasing the likelihood that vulnerable species will go extinct, say scientists. Researchers from the University of Sheffield and University of York in the UK have discovered how deforestation and climate change — two of the biggest drivers of species' extinction — interact with each other to magnify their effects.

For millennia, wildlife around the world has moved up and down mountains and towards or away from the equator to cope with changes in the Earth's temperature. The deforestation of tropical forests is creating a patchwork landscape where natural habitat is disconnected and confined to smaller spaces between a mass of farmland. The research found that most tropical forest habitat is currently too disconnected to provide pathways to cooler climates, meaning wildlife will struggle to escape the impacts of climate change.

Tropical deforestation between 2000 and 2012 led to a vast amount of forest area, bigger than India, losing its ability to link tropical wildlife with a habitat that would protect them from rising temperatures. Today, only 38 per cent of tropical forest allows resident wildlife to avoid climate warming by moving uphill or towards the poles. This loss of forest means that if species move as far as possible to the coldest places along connected temperature gradients, then under severe warming scenarios species would still, on average, suffer 2.6 degrees Celsius in warming.

Rebecca Senior, who carried out this work whilst at the University of Sheffield's department of animal and plant sciences, said, "Our findings are cause for concern. We know that a huge amount of tropical rainforest has been and continues to be converted, but also that habitat loss is not the only threat to the natural world. Our research is the first to investigate this interaction between habitat loss and climate change at such a large scale and over time."

The research was published last week in *Nature Climate Change*.