Further into the ancient universe

The more impressive James Webb Space Telescope is all set to succeed Hubble and is planned for launch in 2014, says s ananthanarayanan

THE James Webb Space Telescope, the major space telescope after Hubble, is planned for launch in 2014. This *infrared telescope*, has been built to detect hardy, low frequency light from the most distant and, hence, most ancient parts of the universe. Telescopes on the surface of earth all view the universe from the bottom of the atmosphere, "an ocean of air" that obscures and distorts the images, apart from being opaque to many parts of the electromagnetic spectrum. Placing a telescope out in space, rather than even the highest mountain top, was first suggested in 1923. But it has taken many years to realise, as it was only in 1957 that *Sputnik*, the first man-made satellite, was placed in orbit.

The first space-based telescopes were deployed in the 1960s and these soon proved their value, so that larger and longer lasting missions were planned. Longer lasting missions meant the need for servicing the facilities during their lifetime and, hence, the need for a reusable space shuttle that could ferry the servicing team to the orbiting observatory.

The Hubble mission, placed in orbit in 1990, is the "size of a school bus", with a main mirror that weighs over a tonne. Soon after launch, a serious defect was discovered in the main mirror, which was corrected during the service mission of 1993! But the telescope has been taking spectacular pictures, in the optical, ultra-violet and the near infrared region for 20 years on and is expected to continue till 2014, at least.

James Webb Telescope

This successor to the Hubble Space Telescope has a mission to view the earliest universe, soon after the Big Bang, and to help understand how galaxies, stars and planetary systems were formed. As light from these early events must needs come from very far images in the ultra-violet, the visible ranges would be dim and obscure, as light at higher frequencies scatters more readily. The interest is, hence, in the near infrared and the JWST is planned with special features that allow precise observations at these lower frequencies. Another reason for interest in the infrared is that because the very distant universe is *receding* at a high speed, the light that comes from there gets *red-shifted*, or lowered, in frequency, just like the whistle of a railway engine falls to a lower pitch as the engine goes past and starts moving away. Light from the distant universe is, hence, anyway at the lower end of the spectrum.

Observation at low frequency, or large wavelength, makes a demand for large aperture optics. The main mirror of the JWST, at about 6.5 metres, would hence be over three times wider than the mirror of the Hubble telescope. As no launch vehicle would be able to contain such a large mirror, it is designed as 18 hexagonal segments that would be assembled as the mirror, and calibrated, once in orbit.

Another constraint of work in the infrared is that all objects at any appreciable temperature are sources of noise. The whole telescope would, hence, have to work at very low temperature, which is an important reason for infrared telescopes to be located in outer space. But the radiation from the sun and the earth would still affect the telescope. The arrangement, hence, includes a large "fan-fold" sun shield to block out this radiation and allow the telescope to cool.

The need to keep the telescope cool also demands that it be placed in a special orbit so that the sun and the earth remain on the same side, and blocked out by the sun shield. This orbit is 1.5 million km from earth, which is four times the distance to the moon. Servicing the telescope would, hence, be a much more complicated task than in the case of the Hubble Space Teelscope!

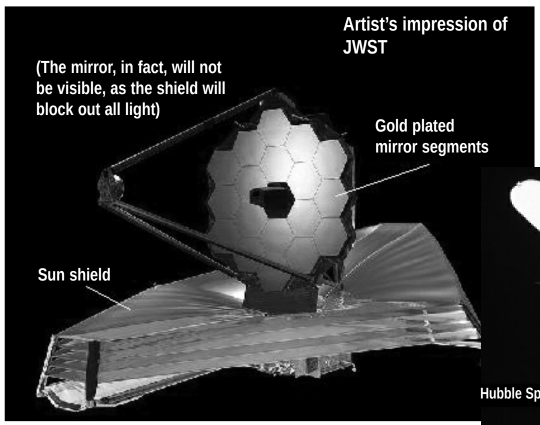
Material of the mirror

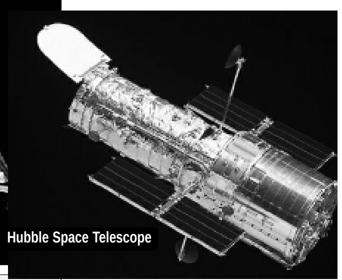
Different surfaces have a different efficiency of reflection. This, of course, is the reason that things are of different colours. Mirrors are usually made of highly polished metallic surfaces. The "silvering" of the usual looking glass is, in fact, a layer of mercury that efficiently reflects all visible colours. But when it comes to reflecting light in the infrared, it is gold and copper that are the most efficient. It is because these metals reflect lower frequencies more efficiently that they are reddish-yellow in colour. The mirror segments for the JWST would, hence, be coated with a layer of gold to work as the reflecting surface.

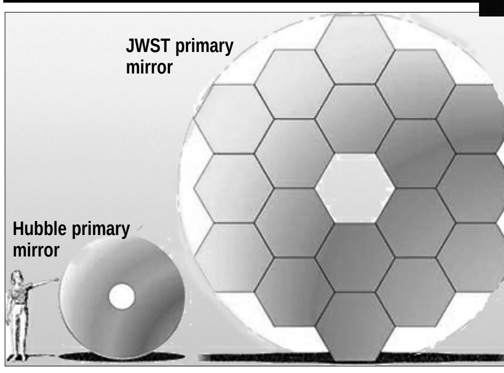
An important milestone in the JWST project was met in October this year when the first of the mirror segments passed the test of being effective at the temperature of liquid helium. This is the test that looks at how the mirror segments change shape and size in extreme temperatures and near vacuum pressure, to make sure that they do collectively work as the intended telescope mirror.

Once all the segments, made of beryllium, clear the cryogenic test in the National Aeronautics and Space Administrations' test facility, the manufacturing process, which is grinding, polishing and coating with a thin layer of gold, will commence, before another round of testing. The schedule for launch is June 2014, which may be shifted to mid-2015.

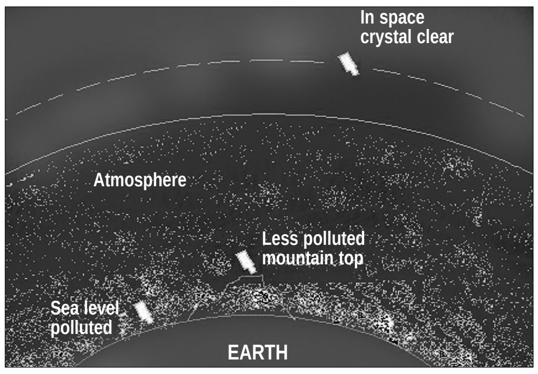
The writer can be contacted at simplescience@gmail.com

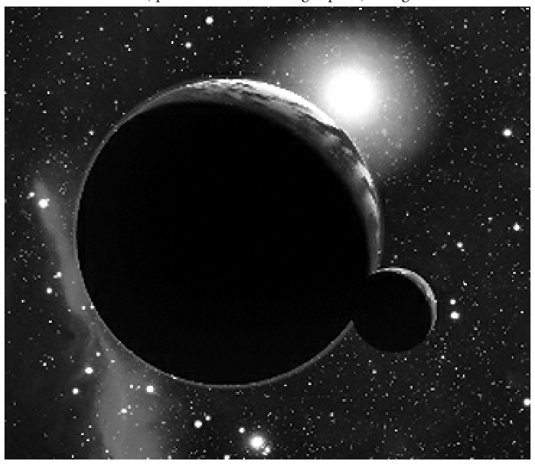






The James Webb Space Telescope compared with Hubble.




For nearby earth-class worlds, JWST may be up to the task, at least for terrestrial planets that transit. In fact, if Alpha Centauri turns out to have a transiting earth-like planet (a major if!), it would take only a few transits to study the light filtering through its atmosphere to look for signs of life. Alpha Centauri is problematic in any case, but a recent study shows that the method — breaking down the star's light during a transit to look for the characteristic markers — could be extended to other stars, provided enough transits can be measured.

The legacy of loneliness

The hope is that scientists will eventually figure out how genes build brains and how electrical activity in the brain builds thoughts and emotions, writes rhishav n choudhury

We are alone, paragons in a world of simple minds.
— Marc Hauser, professor of psychology, human evolutionary biology and organismic evolutionary biology at Harvard University, on the uniqueness of the human mind.

IT is through the mind that we are what we are today. It is how we conceive thoughts, emotions, ideas and reason. We have used it to create language, math, religion, government, technology and capital. It is what wrote *Hamlet*, directed *The Godfather*, painted *A Starry Night*, created television and drafted blueprints for the Taj Mahal. So how and why do our minds allow us to do all this along with every other aspect unique to the human species? Humans share nearly 99 per cent of their DNA with chimpanzees, so whatever makes us human lies in that remaining one per cent. Although it seems very small, the reality is that a genetic difference of even one per cent leads to astounding differentiation. Scaled up, it means a divergence of 15 million genetic bases or "letters" out of the roughly three billion that make up the human genome! These differences in genetic combinations are what differentiate us from all other species.

The human brain shares most of the different cell types along with their chemical messengers with most vertebrate species. We also share the general organisation of the different structures in the brain's outermost layer or cerebral cortex with several members of the primate family. Where we differ is in the relative size of particular regions of the cortex and how these regions connect, differences that give us our uniqueness. These differences in brain wiring have enabled the mental faculties distinctive of our species and given us traits that distinguish us from other animals; our "humaniqueness".

According to Professor Mark Hauser, the human mind is separated from those of animals by four characteristic traits: generative computation, promiscuous combination of ideas, mental symbols and abstract thought.

The first trait is what enables us to create a virtually limitless variety of words, concepts and things. It is made up of two types of operation, recursive and combinational. Recursion is the repeated use of a rule to create new expressions while combinational operation is the mixing of discrete elements to generate new ideas that can be expressed as novel words or musical forms, among other possibilities. The second humanique trait, promiscuous combination of ideas, allows us to combine different domains of knowledge, such as art, sex, space, causality and friendship, thereby enabling us to construct new laws, social relationships and technologies. Mental symbols, the third characteristic trait, allow us to encode both real and sensory experiences, thus forming the basis for a rich and complex system of communication that allows us to keep the symbols to ourselves or express these to others in the form of words or pictures. The last trait is what permits us to contemplate things beyond what we can see, hear, touch or smell. We alone can ponder the universe, God, infinity and death, among other abstract concepts.

The major transformation that led to the make-up of modern humans probably took place during a relatively brief period of evolutionary history, between 800,000 and 50,000 years ago. It was during this period that our species created multipart tools: animal bones punctured with holes to fashion musical instruments, burials with accoutrements suggesting beliefs about aesthetics and the afterlife, and perhaps, most importantly, control over fire, a technology that combined folk physics and psychology. Fire allowed our ancestors to survive in a multitude of environments by creating warmth and cooking food. Humankind is also unique in its ability to create varying cultures between groups, allowing differences in language, musical composition, moral norms and artifacts among other characteristics that are possessed by diverse groups.

No other animal has managed to express itself in such ways, although species do exhibit sophisticated behaviour that appears to presage some human capabilities, such as the ability to create or modify objects for a particular purpose. Male bowerbirds, for example, construct magnificent architectural structures from twigs and decorate these with feathers, leaves and paint made from crushed berries in order to attract females. In addition, research has found that


According to Professor Mark Hauser, the human mind is separated from those of animals by four characteristic traits: generative computation, promiscuous combination of ideas, mental symbols and abstract thought.

"folk physics" enable animals to generalise beyond their direct experiences to create novel solutions to foreign challenges. Orangutans and chimpanzees, for example, were able to access an out-of-reach peanut at the bottom of a plastic cylinder by sipping water from a drinking fountain and spitting the liquid in the cylinder, causing the peanut to rise to the top. Animals also exhibit social behaviour in common with humans, such as readily responding to novel social situations. This kind of behaviour can be observed when, for example, a subordinate animal with a unique skill gains favours from more dominant individuals.

Despite such similarities, the mental gap between animals and us is huge. An example is our ability to combine different materials to create tools for a variety of purposes, whereas animals tend to create tools composed of a single material designed for a single purpose. Another major difference is our language in comparison to animal communication. Although we share a common non-verbal communication system that conveys emotions and motivations, such as the chortles and cries of babies, we alone have a system of linguistic communication based on the manipulation of mental symbols. Human language is remarkable in that it operates equally well in the visual and auditory modes, as in the case of audio-disabled people who use an expressive mode of communication that parallels acoustic language in structural complexity. Our linguistic knowledge, along with the computations it requires, also interacts with other domains of knowledge in ways that reflect our unique ability to make connections between systems of understanding, such as the ability to quantify objects and events to realms far beyond that capable of animals. We can apply our language and number systems to produce new ways of conceptualising the world around us, such as in cases of morality, economics and taboo trade-offs.

Yet, even with all these incredible findings and theories, the roots of cognitive abilities remain largely unknown and the reasons behind the transformation of human minds and the amalgamation of specific characteristics remain a mystery. The hope is that with the discovery of unique traits of the human mind, scientists know what to look for and will eventually figure out how genes build brains and how electrical activity in the brain builds thoughts and emotions. The human mind may have some way to go before it reaches its complete potential, and the present box or bubble that defines the limits of its capabilities may continue to evolve and remodel our genome to give birth to a novel mind, possessing abilities that we cannot even begin to imagine.

The writer is a freelance contributor

Nutrition,metabolism & synthesis

tapan kumar maitra **overviews recent research on forms and properties of bacteria**

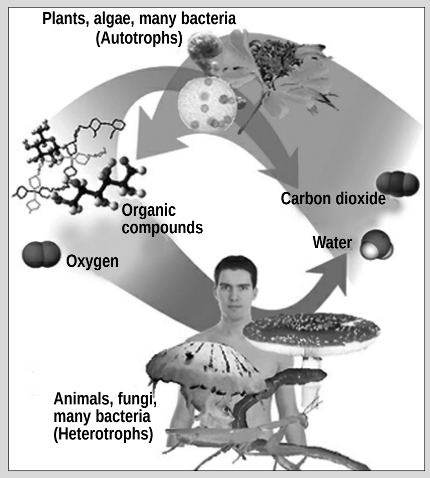
A CONSTANT exchange of compounds with the surrounding environment is inherent in all organisms. To carry out the processes of nutrition and reproduction certain conditions are necessary: the presence of food material from which microbes synthesise the component parts of their cell and by oxidation of different substances, receive the required energy.

Bacteria can be subdivided into autotrophic and heterotrophic, according to their type of nutrition. Autotrophic, chemosynthetic and photosynthetic micro-organisms are able to produce organic substances from inorganic compounds. They do not require organic carbon compounds and synthesise the component parts of their cell by absorbing carbon dioxide, water and simple nitrogen compounds.

Nitrifying bacteria and many sulphur bacteria belong to this category. They synthesise complex substances at the expense of the energy they receive on oxidation of ammonia to nitrites and nitrates as well as oxidation of sulphur, sulphides, thiosulphates to sulphuric acid.

Of particular interest are lithotrophic bacteria, which receive energy from the oxidation of inorganic substances — hydrogen, carbon monoxide, methane, ammonia, compounds of iron, manganese and sulphur. They play an important role in the substance cycle in nature. At the same time they may cause much harm to various constructions — destroy building materials, cause corrosion of metal equipment, destroy about 10 per cent of all oil reserves.

Some species of micro-organisms contain chlorophyll and utilise radiant energy for photosynthesis. During synthesis all cellular organic substances utilise carbon dioxide as the sole source of carbon and are unable to absorb more complex carbon compounds; for which



Overview of cycle between autotrophs and heterotrophs.

reason such organisms cannot be pathogenic for man and animals.

Certain autotrophic bacteria possess the property of utilising polyethylene, nylon, diesel fuel, boric acid, phenol and other inorganic substances.

Heterotrophic bacteria require organic carbon, various nitrogen compounds (nitrates, ammonia), inorganic substances, trace elements and vitamins. Micro-organisms that may change from one type of nutrition to another are called mixotrophs. Heterotrophic bacteria are subdivided into saprophytes and parasites. Saprophytes live at the expense of organic substances found in the surrounding environment. Parasites make up a comparatively small amount of species of microbes, which in the process of evolution have adapted themselves to a parasitic mode of life.

Some scientists call them paratrophs since they feed at the expense of organic compounds of animals and man. However, this kind of subdivision of heterotrophic microbes into saprophytes and parasites is not absolute. Certain species of microbes pathogenic for man can exist in the environment as saprophytes and some of these cause different diseases in humans and animals.

It has been established that some microbes, which were earlier considered to be typical heterotrophs, grow well on synthetic media containing ammonium sulphate supplemented by vitamins. Many pathogenic micro-organisms cultivated on media containing blood and serum can be grown on synthetic media. The majority of bacteria develop only on complex media containing peptone — a product of enzymatic breakdown of meat and other protein substrates —, meat extract and products of a similar biological origin, which contain all the organogenes in the form of highly molecular compounds necessary for the nutrition of microbes.

B Knight divided bacteria into four groups according to their ability to synthesise complex compounds:

- Bacteria obtaining carbon from carbon dioxide and nitrogen from inorganic compounds. These include autotrophs capable of photosynthesis. Such organisms utilise radiant energy (light). Autotrophs capable of chemosynthesis obtain energy by the simple processes of oxidation of inorganic compounds — nitrifying bacteria, sulphur bacteria and some iron bacteria;
- Bacteria deriving carbon and obtaining energy from organic carbon compounds and nitrogen from its inorganic compounds;
- Bacteria obtaining carbon and energy from organic carbon compounds and nitrogen from amino acids; and
- Bacteria absorbing carbon and obtaining energy from organic compounds and nitrogen from a complex of many amino acids, requiring one or more vitamins — pathogenic bacteria.

The main difference between heterotrophic and autotrophic organisms is that they require organic compounds containing an asymmetric carbon atom. However, recently it has been proved that separate species of heterotrophic bacteria, protozoa, yeasts and also animals absorb carbon dioxide and ammonia, synthesising complex carbohydrates and amino acids from them. The normal inhabitant of the human intestine E. coli, for instance, grows well on a synthetic nutrient medium containing NH_4CL and $MgSO_4$.

The writer is associate professor of botany, Ananda Mohan College, Kolkata