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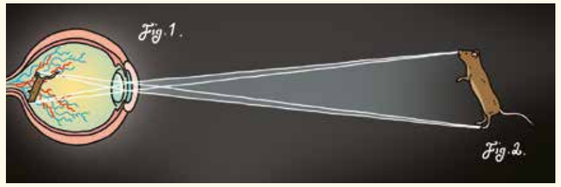
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Unlocking the scientific secrets of sight

FROM OUR MAN IN THE MAGHREB,
Cairo, 1021

IMAGINE A TECHNOLOGY that would allow humans to zoom in so they could see the Moon and stars close up – as if they were in space! The scientist Ibn al-Haytham believes one day such a technology may be possible.

In his recent *Book of Optics*, the Muslim scholar puts forward a new theory explaining the science of how people see. Scholars believe his ideas may one day lead to the development of techniques for viewing distant objects, perhaps even the stars, close up.



Mr al-Haytham disagrees with the classical philosophers Euclid and Ptolemy, who argued that our eyes shoot out particles of light that illuminate objects, allowing us to see them. Instead, he says some objects reflect light from the Sun while others absorb it. Either way, the light that reaches our eyes is what creates the images we see. He points to the implausible notion that the eyes could light up an area as big as the night sky when they are open; it is much more likely, he says, that the Sun, Moon and stars are shining down on us.

Mr al-Haytham also discusses the concept of magnification, which has excited many scientists. Using this technique, he believes it will one day be possible to bend light so that objects look closer. Scholars hope that it might also be employed for viewing distant, mysterious objects or observing tiny creatures in fine detail.

Mr al-Haytham began his career as an engineer in Cairo, working for the Caliph. He started experimenting with optics after the failure of a huge project to control the flooding of the River Nile. After avoiding the Caliph's wrath, by pretending to be mad, Mr al-Haytham was able to focus his curiosity on the scientific investigations that have led to his groundbreaking *Book of Optics.*

House of Wisdom leaves Europe in dark

Baghdad becomes new seat of learning after caliphs order translation of ancient texts

BY OUR MIDDLE EAST EDITOR,
Baghdad, 1025

THE REDISCOVERY of ancient Greek and Roman wisdom is spurring new discoveries in medical and scientific thought throughout the Middle East. While much of Europe has been prey to intellectual drought since the fall of the Roman Empire, scholars across the Muslim world are busily translating, studying and developing ideas based on these classical ancient texts.

In Baghdad, a scholarly institution supported by the caliphate known as the House of Wisdom is now one of the largest repositories of knowledge from the ancient world. Since the introduction of convenient, affordable papermaking techniques from China, the caliphs have commissioned the translation of hundreds of texts into Arabic, ensuring that the study of science is a priority under their rule.

The works of Greek philosopher Aristotle were amongst the first to be translated, and his philosophy is now basic reading for all Muslim scholars.

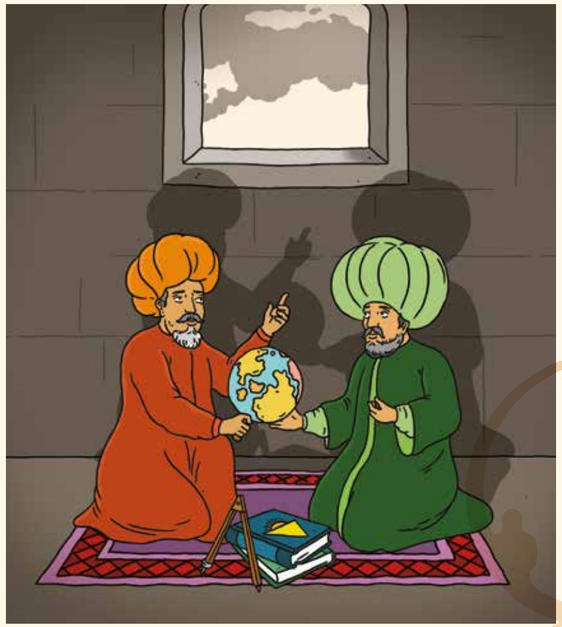
Earlier this year, a doctor from Persia called Avicenna announced the release of his fourteen-volume *Canon of Medicine.* This encyclopaedia draws upon the discoveries and ideas of Aristotle and Galen to investigate the body and its various illnesses. It also details suggestions for healing and maintaining good health.

Mr Avicenna believes that exercise is key to healthy living, helping to stave off disease. He also provides information on how plants and herbs can be used as painkillers, medicines or even contraceptives.

Mr Avicenna says rigorous testing must be carried out before using any new drug or medicine. Perhaps most importantly, Mr Avicenna says new drugs should be tested on humans, not just animals, since he believes that what is good for an animal is not necessarily good for a human.

Mr Avicenna's discoveries about the human body are already being taught in libraries and schools across the Muslim world.

Other Greek, Roman, Persian and Indian works have also been translated and spread across the Arab world, leading to the rise of other centres of Muslim scholarship, for example in Córdoba in Andalucía. Here a rival government to the rulers of Baghdad was established in 756 by Abd ar-Rahman, a prince of the deposed Umayyad royal family who refused to recognise the authority of the Abbasid caliph in Damascus.



New irrigation techniques are now being deployed across Iberia to improve harvests and enable the cultivation of new crops such as watermelons, rice and bananas. Commentators consider that ever since the collapse of the Roman Empire in the fifth century AD, Christian Europe has been left far behind the Muslim world in terms of scientific understanding.

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Bleeding and plants are keys to healthy life

BY OUR MEDICAL EDITOR,
Bingen, Germany, 1150

A VISIONARY female theologian, the poet and scientist Hildegard of Bingen, has just completed a new work on the human body and its ailments. The work promises to help alleviate many of the world's most pernicious afflictions and diseases.

Ms Hildegard has already proved her ample knowledge of the natural world in Physika, *a work that focuses on the medicinal properties of plants, minerals and animals. Ms Hildegard's latest work,* Causes and Cures, *lays out her specialist medical and anatomical thinking.*



In her work, Ms Hildegard recommends 'bleeding' a patient as a cure for many conditions. This technique, which involves letting bad blood flow out, has been in use since ancient Greek times, but Ms Hildegard describes in great detail how it should be done, including how much blood to take and even which phase of the Moon it should be performed under. She also presents remedies for burns, fractures, dislocations and cuts.

Ms Hildegard's strong belief is that since everything was put on Earth by God for humans to use, it is no wonder that cures for a wide variety of diseases can be found in various plants and minerals. In her book, Ms Hildegard has developed a classification system for all the organisms mentioned in the Book of Genesis.

Ms Hildegard says her inspiration has come from a series of visions that she has experienced throughout her life, as well as through the five senses – sight, hearing, taste, smell and touch – all of which she claims are gifts from God.

Renaissance man says fossils no proof of Biblical flood

BY OUR RESIDENT POLYMATH,
Monte Rosa, Switzerland, 1510

WHAT'S A FOSSIL? The origin of these strange shapes found in rocks around the globe is a mystery that has long puzzled scientists. Often they take the shape of animals and plants not found living on the Earth, seemingly frozen in time. Now a new explanation has been proffered by the celebrated Italian polymath, Leonardo da Vinci.

Mr da Vinci has dedicated much of his professional career to drawing diagrams for bizarre inventions such as helicopters, steam-powered cannons and mechanical soldiers. Now he has turned his curiosity to the natural sciences, observing birds in order to design his own flying machines and, through fossils, studying the ancient history of the Earth itself.

Perplexed by the many fossilised marine molluscs that are found high in the Alps bordering Switzerland and Italy, Mr da Vinci has pondered how these sea creatures came to be so far from water. Two common explanations exist: that a great flood sent by God submerged the mountains; or that these are formations that have simply grown in the rocks. Mr da Vinci disagrees with both theories.

"A worldwide flood is quite simply an impossibility," he says dismissively. "Where did all the water go? And as for these being an ordinary feature of the landscape, one can clearly see from the distinct layers of rock, which are laid down throughout Earth's life, that these creatures appear only at a certain time in history and bear a similarity to fossils found by the coasts."

Mr da Vinci maintains that these mountains were not always mountains – long ago this was an area of coastline or ocean, now raised high. In his view, fossils provide evidence to suggest that the Earth's shape is constantly changing.

Mr da Vinci has also been studying human anatomy, even creating the first study of a foetus in the womb, all to help him improve his painting.

"As an artist," he says, "understanding the skeleton and muscles to draw realistic figures is just as important as it is for a doctor to give the proper medicine. I have been working with physicians across Italy to create detailed drawings of the human body that will not only inform my work but also, I hope, further medical knowledge."



Dissections reveal body's secrets

THE GRUESOME DISSECTION of a human corpse took place yesterday in Basel, Switzerland, when radical surgeon Andreas Vesalius invited the public to watch him explain the inner workings of the human body. Mr Vesalius cut open the cadaver of local criminal Jakob Karrer von Gebweiler, preserving the skeleton for public display, *writes our medical editor from Switzerland on 13 May 1543.*

Mr Vesalius claims that dissecting humans, which is a long-standing taboo in many European countries, is a necessary technique for the proper study of anatomy. The Belgian surgeon hit the headlines two years ago when he pointed out that the anatomical works of the Greek physician Galen, long considered the ultimate authority, are based on flawed animal dissections.

In Mr Galen's time, the Roman Empire banned all dissection of human bodies but now, although controversial, such research is permitted. Thanks to his human dissections, Mr Vesalius has identified errors in Mr Galen's work.



For example, he has found that human jawbones are made of one hinged bone, not two as proposed by Mr Galen. As a result of Mr Galen's failings Mr Vesalius is now sceptical of relying too heavily on the classical thinkers, feeling that their lack of carefully repeated examination, and their merging of philosophy and medicine, has led to serious mistakes.

Mr Vesalius has also debunked some common misunderstandings about the body, including the belief that men have one rib fewer than women, a myth originating with the story of Adam and Eve. Mr Vesalius plans to publish his discoveries accompanied by detailed illustrations.

A fourth mass extinction spells doom for many non-dinosaur archosaurs. Pure reptiles return to the seas where they evolve into fierce marine predators. Pterosaurs ('winged lizards') launch into the skies. From the forests, where Carboniferous-era lycopods and clubmosses are slowly eclipsed by seed-bearing conifers, ginkgos and cycads

Mammals survive in a world dominated by dinosaurs thanks to a range of adaptations. Fur insulates their bodies so they can hunt at night when the dinosaurs are asleep. Many give birth to live young, rather than lay eggs that might otherwise be eaten. Feeding with breast milk means they do not have to leave their offspring exposed when danger lurks

Giant sauropod dinosaurs such as *Diplodocus* roam the Cretaceous landscape. *Archaeopteryx*, the oldest known dinosaur with feathery wings, takes to the skies, ushering in the era of birds. The first flowering plants splash the landscape with colour, attracting insects, birds and mammals with their sugary nectar and juicy fruits

Rising magma in deep sea trenches forces parts of Gondwana to begin to split into Africa and South America, separated by a growing expanse of ocean. Animal and plant species are isolated on giant continental rafts, diversifying as climates change. 'Monocot' plants pioneer a radical new pattern of growth by sprouting outwards from a central bud

Coccolithophores, microscopic lifeforms with calcium carbonate shells, proliferate in the Cretaceous seas, falling to the sea floor as sediment that eventually turns to chalk. The climate begins to cool as the continents slowly shuffle around the globe. Antarctica heads towards the South Pole while India breaks loose on a journey north-east

Ornithomimus and Struthiomimus are among the last dinosaurs to wander the Earth as the world lurches towards a fifth mass extinction. This one wipes out all non-avian dinosaurs, pterosaurs and all the marine reptiles, but birds, crocodilians, turtles and mammals scramble through. The world now offers fresh ecological possibilities for the survivors

Although fallout from the meteorite impact triggers an ecological catastrophe, small mammals seize the opportunities of a new dawn. Free from the fear of dinosaur attack, they now begin to grow larger, found in the dazzling array of diversity into forms we are familiar with today

JURASSIC

CRETACEOUS

PALAEOCENE

-3°C

-2°C

+1°C

+0.5°C

DIPLODOCOIDEA: A big-headed plesiosaur with a wingspan of about 13m

ARAUCARIA: A tall monkey-puzzle tree with spiky, zappedy branches designed to bamboozle the plant-eating, long-necked sauropods. Over millions of years the herbivores' relatives of monkey puzzles are transformed into the bony-to-eat modern araucarias

VOLATICOTHERIUM: An insect-eating mammal that glides through the air like a modern flying squirrel

ARCHAEOPTERYX: A primitive bird about the size of a raven but with dinosaur features such as sharp teeth, three-fingered claws and a long bony tail

TEMPSKYA: A unique design of tree with a false trunk of branching stems

KUANGDON: A bulky herbivorous dinosaur with vicious thumb spikes for warding off predators

ARCHAEOLEPIS MANE: The earliest known member of the butterfly-moth family (Lepidoptera)

GINGKO: These trees spread throughout the Jurassic but decline thereafter – only one species remains today

PLATEOSAURUS: An early herbivorous prosauropod dinosaur (one of the first long-necked species) and among the first to grow to a gigantic size (up to 10m long)

ALLOSAURUS: A giant 12m-high theropod dinosaur with one of the most powerful bites of any creature that has ever lived

DILOPHOSAURUS: A 6m-long theropod with three toes on each foot and a pair of rounded crests on its head

MEGALOSAURUS: The first dinosaur – a large meat-eating theropod – to be discovered, described and named by humans

SCELIDOSAURUS: An early heavily armoured 4m-long herbivorous dinosaur with leaf-shaped teeth

DIPLODOCUS: At 27m long from head to tail, this sauropod giant feeds off trees, ferns and bushes. Its huge size provides protection against carnivore attack

STEGOSAURUS: A 9m-long, heavily armoured herbivore with a spiked tail for whipping predators. Its 80g brain may be the smallest amongst dinosaurs

KENTROSAURUS: A herbivorous stegosaurid dinosaur with a double row of spiky plates on its back to deter predators

ANTARTICYCAS: These shrubs are related to modern cycads. They are well adapted to living in polar regions where sunlight is dim

HETERODONTOSAURUS: A small, fast-moving herbivorous dinosaur with large canine teeth and five-fingered 'hands' for grasping food

ARCHIDERMAPTERA: The earliest form of earwig

MEGAZOSTRODON: The first true mammal. This small, furry animal hunts at night and eats insects and small lizards

FRUITAFOSSOR: A small, burrowing, ant-eating mammal

HALDANODON: A mouse-sized mammal with a long, narrow snout

PROSALIRUS: This frog-like amphibian appears 55 million years before Sanjeonkhan, the first modern frog

STENEOSAURUS: A 4.8m crocodile with an elongated snout that attacks shoals of fish from below

ICHTHYOSAURUS: A 2m-long marine reptile that gives birth to live young (viviparous)

HYPERLIOCERAS: A Jurassic ammonite

PLESIOSAURUS: A 5m-long marine reptile with a small head, long neck and turtle-shaped body that feeds off fish and belemnites

AEGER: Ancient prawns

PSEUDOGLYPHEA: A primitive lobster

CASTOROCAUDA: A small, semi-aquatic mammal that looks similar to the modern beaver, otter and platypus

PROTEROCTOPUS: A small, primitive octopus – the earliest that is known

BELEMNITE: A squid-like cephalopod with 10 arms but no tentacles. It uses a series of hooks for grabbing prey

DOLLOCARIS: A large crustacean with bulbous compound eyes

BOSITRA: A small, well-protected clam that swims by clapping its shells

4TH MASS EXTINCTION

TERMITES

Worker

Soldier

Queen

These nest-building insects are descended from cockroaches and develop complex social organisations. Their bodies adapt to perform different functions, such as worker (for building), soldier (for defending) or queen (for breeding)

DIATOMS

These microscopic algae form a major component of the sea's food chain, essential for the survival of many molluscs and fish. They are encased in porous cell walls made from silica. Some are cylindrical, others are elongated

FORAMINIFERA

Microscopic amoeba that produce shells made from calcium carbonate. Fossilised forams frequently feature in sedimentary limestone, such as that used to build the Egyptian pyramids

PTERANODON: A large flying reptile with a toothless beak, large cranial crest and a wingspan of more than 5m

CONFUCIUSORNIS: A crow-sized bird with a toothless beak and a short tail

MICRORAPTOR: A transitional species of theropod dinosaur that may have been able to glide through the air using four feathered limbs for lift

SINODELPHYS: The earliest known marsupial is an expert at climbing trees

SINOSAUROPTERYX: One of the first dinosaurs NOT in the class of birds to have feathers, probably for body insulation

DEINONYCHUS: An agile predator with a sickle-shaped second toe on its hind legs for kicking prey to death

LAPPARENTOPHIS: An early burrowing snake – reptiles that are descended from lizards

EOMAIA: An early placental mammal

NYMPHAEALES: Water lilies are one of the oldest orders of flowering plants (angiosperms)

LYCOPTERA: A small freshwater fish that feeds off plankton

LEPIDOTES: An ancient fish with a deep/robotic jawbone, allowing it to suck in prey from a distance

KRONOSAURUS: A 10m-long marine predator belonging to a family of short-necked reptiles called pliosaurs

SAULT: An ancient crab ancestral to modern species

MONOCOTS VS DICOTS

Two different designs of flowering plants emerge. Dicots usually have leaves with networks of veins and petals in multiples of four or five. Monocots have leaves with parallel veins and petals in multiples of three

ONYKRAPTOR: A theropod dinosaur that broods over its eggs like a chicken

SABALITES: A monocot in the palm family Arecaceae. Palm leaves grow outwards from a central elevated bud, protecting their newest growth from being grazed by animals

VELOCIRAPTOR: A vicious two-legged, feathered, turkey-sized dinosaur with sickle-shaped claws and jagged teeth for ripping prey

PROTOCERATOPS: A herbivorous horned dinosaur that is about the size of a sheep, with a large frilly neck

TRICERATOPS: A three-horned herbivorous dinosaur with a large bony frill used for both protection against predators and courtship displays

POLLINATION

Flowering plants, insects and mammals co-evolve in mutual advantage. Flowers provide food and sugary fruits for animals, while animals spread the plants' pollen and seeds

AMBORELLA: One of the most primitive flowering plants

SANSHANLICHAN: The ancestor of modern frogs

MAGNOLIA: An ancient flower family

COCCOLITHOPHORES

These microscopic organisms secrete hard outer plate-like shells made from calcium carbonate

ACANTHOTTA: Ancestral songbirds (Passeriformes) emerge in New Zealand, a family (not including blackbirds, sparrows, robins, larks, finches, warblers and wrens

QUETZALCOATLUS: A toothless pterosaur with a long, stiff neck and a wingspan of about 11m

PARASAUROLOPHUS: Some hadrosaurs are notable for their distinctive head-ornaments – perhaps used for identifying species

BURMACULEX: A primitive mosquito. Females suck animal blood as a source of protein for egg-making. Males feed off pollen and nectar

SUSUCHUS: A fast-walking reptile ancestral to modern crocodiles

MAIASAURA: A large, duck-billed herbivorous dinosaur that raises its young in nesting colonies

KOOLASUCHUS: A 5m-long temnospondyl amphibian that survives in Australia long after similar creatures become extinct

ANISOCERAS: A small, spiky, U-shaped ammonite

CLADOCYCLUS: Primitive bony fish from the family Ichthyodectidae

MICRASTER: A small sea urchin with five-fold symmetry

INOCERAMUS: A bi-valve Cretaceous clam

CHALK DEPOSITS: Coccolithophores have a cooling effect on the climate by depositing dissolved carbon from the atmosphere in calcium carbonate sediments that accumulate on the sea floor. Over millions of years, these sediments are compacted into chalk

65m MASS EXTINCTION: A giant meteorite strike (near Mexico) and a volcanic apocalypse (in India) provoke a mass extinction that kills off the non-avian dinosaurs, pterodactyls and mosasaurs

GLOBAL WARMING: The climate rises by 6°C in 20,000 years, paving the way for Eocene thermal maximum

PREDYORNIS: Ancestors of birds that eventually diversify into ducks, geese, swans and waterfowl

OAKS: Wind-pollinated flowering trees spread throughout the northern hemisphere

FORMICIUM: These giant ants grow up to 3cm long and have a wingspan of 10cm across. Ants spread across the world boosted by the spread of flowering plants

MIACIS: A carnivorous distant ancestor to cats and dogs

PHENACODUS: A small hoofed condylarth mammal and possible forerunner of odd-toed ungulates (mammals with hooves). Modern descendants include horses, tapirs and rhinos

PLESIADAPIS: A primate-like mammal, adept at climbing trees, that evolves in North America and crosses to Europe via Greenland

FICUS: Figs are one of the earliest flowering trees in the Rosid family. They co-evolve with small species of wasps that pollinate their flowers

CORYPHODON: A 2m-long herbivorous mammal – one of the largest of its day

PTILODUS: A small squirrel-like mammal

WAIPARA: An ancestral penguin

GUARINISUCHUS: Crocodiles are one of the few large reptile families to survive the dinosaur mass extinction

LEPISOSTEUS: Primitive ray-finned fish with heavily armoured scales and sharp teeth

ARCHELON: A giant 4m-long, 5m-wide squid-eating sea turtle that is covered in a large leathery shell

TYLOSAURUS: This giant 15m-long predatory marine lizard, called a mosasaur, has a crocodile-like bite and razor-sharp teeth

OIL DEPOSITS

The remains of marine life from the Tethys Sea is trapped beneath the Earth's crust, burying what become vast deposits of Middle Eastern oil and gas

Porous rock

Non-porous rock

Gas

Oil

DAGNATIS: An ancient stingray with venomous spines on its tail that belongs to the cartilaginous fishes (Chondrichthyes) – the same class as sharks

CAMINALIS: A 60cm-long giant sea snail

ELASMOSAURUS: A 14m-long plesiosaur with a giant neck containing 70 vertebrae, a record for animals with backbones

DINOSAUR EXTINCTION

1 unit = 1 million (M) years

1 unit = 1 million (M) years