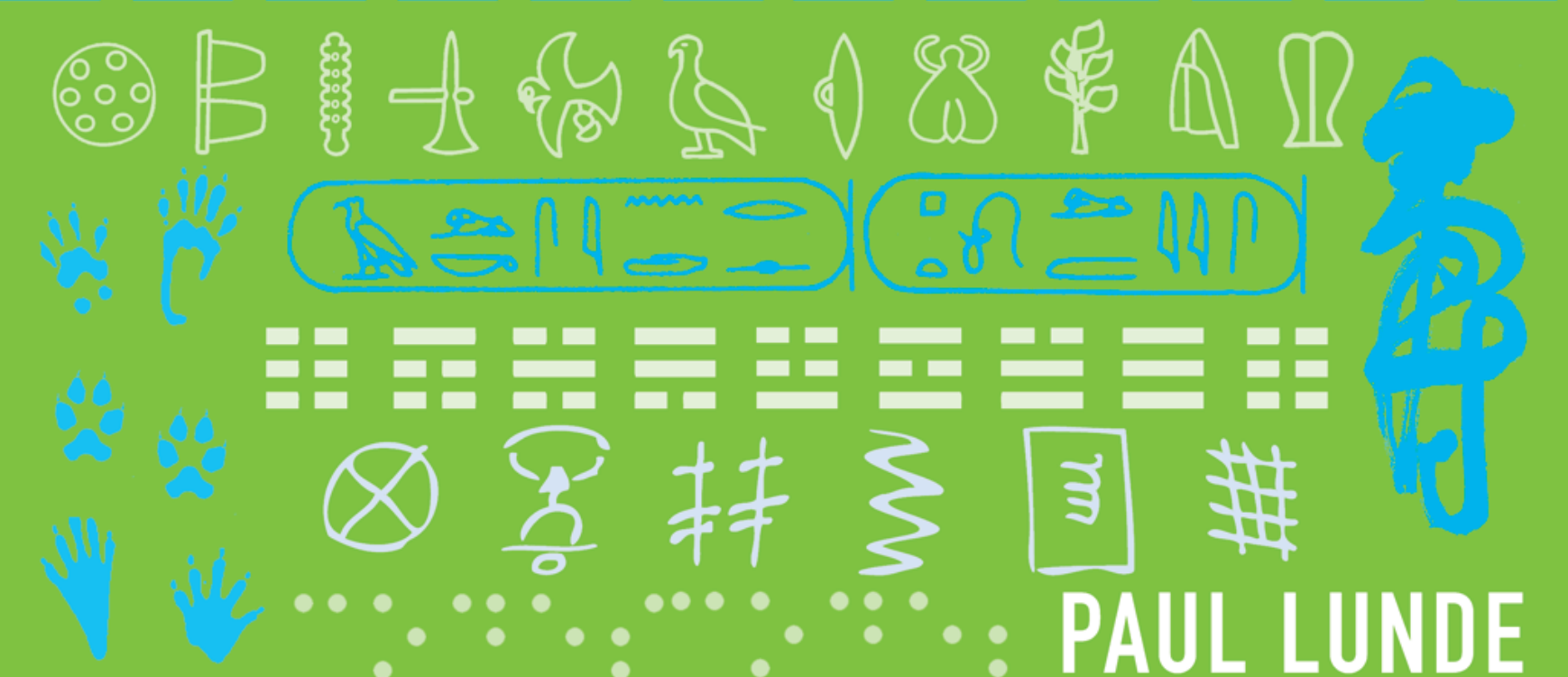
the secrets of

signs • symbols • cyphers & secret languages

codes



PAUL LUNDE

understanding the world of hidden messages

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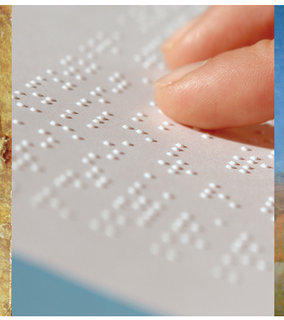
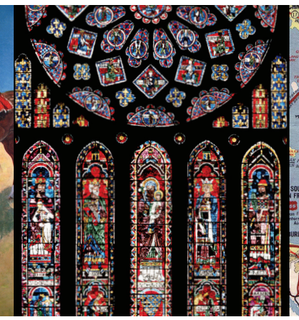
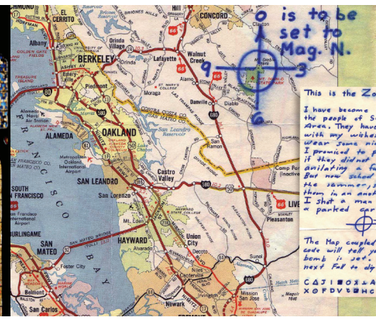
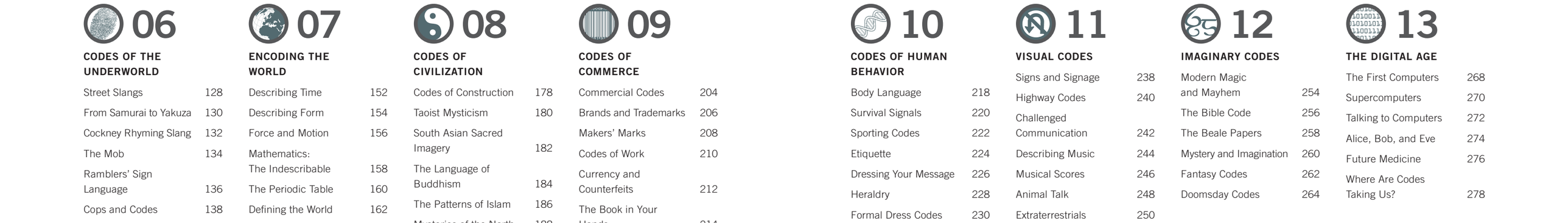




BUSHCRAFT SIGNS

Although there are various theories about how and when the first spoken languages evolved, little is truly known, although we live today with the 'Tower of Babel' legacy. What is more clear was the necessity among migrant hunting groups for a sophisticated means of silent communication, involving hand signals and body language while stalking, and the ability to provide signals and instructions to others from the same group or tribe concerning their movements. We can find examples of these among many primitive cultures the world over today, and some have been adopted and adapted by modern hunters, armies, and organizations like the Scouts.

Penan twig codes

The Penan hunter-gatherers of Sarawak, Borneo still use an ancient field message system involving cut twigs.

Indicates direction to follow

Must follow

Hurry up

Long way

Be there in three days

No food, but in good mood

Be warned, do not follow us

Indian signs

One of the most comprehensive systems of signs used whilst stalking game known to us today was developed by the Plains Indians. These involved both complex body language and hand signs, and images that could be drawn (*left*). In addition, the Plains Indians developed a complex signing language which allowed them to overcome the language barrier between tribes (also achieved among the Aboriginal tribes of Australia's Western Desert), and also acted as a primal form of signing for deaf people (*see page 242*).

US military personnel learned Native American hand sign language.

Water in this direction

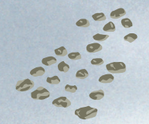
Turn (left or right)

This way

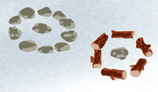
Not this way

This way over obstacle

Party split up



Message this way



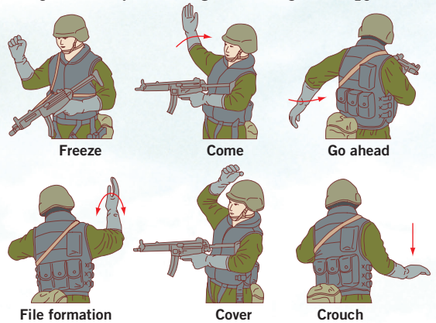
Gone home

Field information signs

While many hunting and gathering groups such as the San Bushmen of the Kalahari Desert and the Penan of Borneo (*opposite*) developed their own, unique bushcraft signals and ways of leaving messages, it was from encounters with these systems that an internationally recognized vocabulary of bushcraft signs was developed, initially by colonial military troops, and latterly by the Scouts movement. These are designed to provide information for other people or groups in the field, and are closely linked to the vocabulary of modern survival signs (*see page 220*). These signs may be drawn in the sand or earth, or constructed from available materials such as sticks or boulders.

Military signs

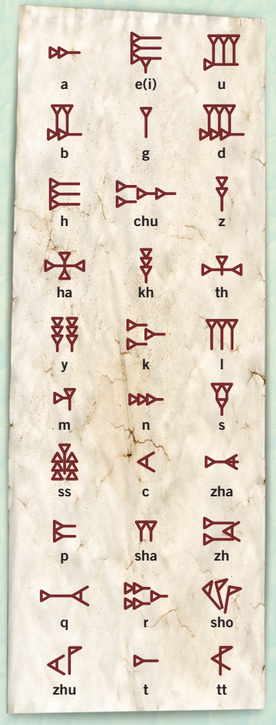
In combat or search-and-find situations, silent communication in the field can be a matter of life or death. The US military uses a system of hand and body signaling which closely resembles that used by other armed forces, and is designed to communicate key information to fellow soldiers, and to potential suspects who might not speak English.



Shadow Wolves

Bushcraft skills are still important today. An elite US police unit, the Shadow Wolves, composed of Native Americans from a number of peoples including the Navajo and Blackfoot, use traditional tracking techniques to hunt down drug traffickers along the US/Mexican border. They have impounded over 45,000 pounds (20,412 kg) of marijuana since 1972, and have traveled to Central Asia and Eastern Europe to teach tracking skills to local police officers.

ALPHABETS AND SCRIPTS



Ugaritic remains the earliest known alphabet. Dating from c.1400 BC, it was written in cuneiform. It originally comprised 22 consonants, but grew to 30.

The earliest consonantal alphabet was written in cuneiform in the city of Ugarit on the Syrian coast c. 1400 BC, but the order of the signs suggests that it was influenced by an alphabet similar to the somewhat later Phoenician, the earliest example of which dates to 1000 BC. The latter was spread throughout the Mediterranean by Phoenician traders. The Greeks perfected the system by adding signs for vowels, while to the east, in India and Southeast Asia, syllabic alphabets, possibly inspired by Aramaic letter forms, were brought to an extraordinary degree of phonetic perfection. Curiously, Akkadian cuneiform and Egyptian hieroglyphics continued to be written in the traditional way for 1,000 years after the invention of this much simpler way of writing.

Abjads and abugidas

Ugaritic was closely related to Phoenician, Canaanite, and Aramaic, as well as to Hebrew. Such Semitic alphabets, consisting solely of consonants, are today called 'abjads,' after the first three letters, aleph, beth, and gimel, the sign for aleph representing not the vowel 'a,' but a glottal stop. Almost all scripts used for Semitic languages are abjads. Scripts like Ethiopic, which developed from the South Arabian abjad, but modified the shapes of the letters to indicate following vowels, are known as abugidas (*see Devanagari, opposite*). Most Indian and many Southeast Asian scripts are of this type.

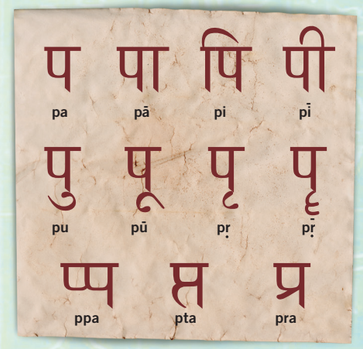
The Greeks adopted the Phoenician alphabet (*below*), but although well adapted to writing Semitic languages, a consonantal script was clearly inadequate for a vowel-rich language like Greek. Signs that represented Semitic sounds not present in Greek were assigned vocalic values, and after much regional experimentation, the first 'true alphabet,' in which every sound of the language could be represented by a single sign, was formed. The Greek versions of the Phoenician names of the first two letters of the Greek alphabet, *alpha* and *beta*, give us our word for 'alphabet.'

Knowing your Ps and Qs

The Roman alphabet, which forms the basis of the modern Western writing system, first appeared in inscriptions in the 6th century BC, and was probably derived from Etruscan. Originally it comprised only 21 letters, 'V' standing for both the sounds 'V' and 'U' and 'I' standing for both 'I' and 'J.' 'U' was not distinguished from 'V' graphically until the 10th century, and 'W' – originally two V's written side by side – did not appear until substantially later. 'J' was finally assigned its own graphic form in the 15th century. Italian still rejects 'K' for a hard 'C,' preferring the digraph 'CH.' Special letter forms and diacritics have been adopted for certain sounds in Scandinavian and some Central European languages, as well as Turkish.

Syllabic alphabets and syllabaries

The letters of a syllabic alphabet normally indicate consonants plus vowels by modifying the shape of the consonant letter, or by adding diacritics, or both. These alphabets are richly represented in the many complex scripts of the Indian subcontinent. The Bhahmi script is the oldest (c.300 BC), and the Devanagari (*right*) is the most widespread. A true syllabary, with a separate sign for each possible combination of consonant and vowel, would have several hundred characters. Syllabic alphabets instead modify the shapes of the letters depending on which vowel follows or precedes it. Japanese Hiragana and Katakana, and the Korean Han'gul script (*below*), are examples, and such syllabic alphabets are used to write Inuit and other North American Indian languages.



Devanagari script An example of an abugida showing how a single consonant sign is adapted to show its syllabic values.

The Korean Han'gul script is an elegant syllabary, in which the consonants and vowel sounds are treated separately, the vowel sounds acting as modifiers to the consonants.

The Roman alphabet was used not only throughout the western empire, but was carried much further by Christian missionaries in succeeding centuries, which explains its modern predominance. In the Orthodox east, Greek was still used; a new alphabet was developed by Byzantine missionaries in the 9th century which combined features of both Latin and Greek, adapted to translate the scriptures into Old Church Slavonic. Its use was spread by Saints Cyril and Methodius who led missions into eastern Europe and Russia, and where it took root and became known as Cyrillic (*right*). Its 33 letters lend themselves to Slavonic vowel sounds, and it is currently used to write some 50 Central Asian languages across the former Soviet Union.

Chinese script

First appearing as a fully developed script on oracle bones from c.1200 BC, Chinese has developed over the centuries using four fundamental types of character: pictographs, visual representations of objects; differentiated characters, not pictorial, used for various relational and abstract ideas; associative pictographic compounds, made up of two semantic elements – two graphic components whose meanings taken together suggest another word; and phonetic compounds drawn from either semantic or phonetic signs which, when combined, indicate pronunciation and meaning. The latter are used for some 90% of modern Chinese writing. Chinese today comprises some 60,000 characters, although less than 4,000 are normally used.

Writing Chinese requires knowledge of a huge number of characters.

	Pictograph Horse	Differentiated characters Upwards, rising	Pictographic compound Sunset, ending	Phonetic compound Willow
c.1200 BC for divination				
c.1500 BC for religious purposes				
221 BC for proclamations or names				
c.200 BC for official texts or literature				
c.AD 200 for official texts or literature				
c.AD 1400 for general use				
1956 for general use				
c.AD 200, for drafts, notes, and letters				

INDIGENOUS TRADITIONS

There are today thousands of 'lost' cultures, many highly sophisticated, with rich traditions, rituals, and myths, with equally complex means of expressing and commemorating them. Many oral traditions in the Americas, Africa, and Australasia have been eroded by the relentless rise of globalization. However, there remain some enigmatic fragments through which, like Mayan glyphic writing (*see page 36*), a rich but lost past can at least be glimpsed.

A lost heritage

Totem poles are a striking feature of Pacific Northwest indigenous peoples, and are found from southern Alaska to northern Washington State. The word 'totem' is derived from Ojibwa or a related language, and means 'kinship group.' One of the principal functions of the totem pole was to record family and clan legends, lineages, and notable events. When they were created they could be 'read' by the members of the clan or family that erected them, but as they decayed their meaning was usually lost. Their message could simply be to proclaim the successes of a family or individual, commemorate a notable potlatch ceremony, or tell a legendary or historical story. 'Shame' poles were erected as symbolic reminders of unpaid debts, quarrels, murders, and other shameful events that could not be publicly discussed. One such pole was recently erected in Cordova, Alaska depicting the upside-down head of Exxon ex-CEO Lee Raymond.

The carvings would represent the crest of the person or clan concerned, indicating their moiety – Eagle or Raven – and their lineage. The Haida alone, for example, had some 70 crest figures, of which only about 20 were in common use. The following groups of animals are frequently associated with the Eagle or Raven moieties:

Eagle	**Raven**
Fish	Skate
Amphibians, such as frogs	Sea mammals
Beaver (considered amphibian)	Land mammals (except beaver)

The designs of the figures on totem poles were specific to each clan, although there were some, like the Thunderbird surmounting this pole, that were common throughout the area.

Totemic imagery

The style of totem carving varies among the Haida, Tlingit, Kwakiutl, and other Northwestern and Coastal First Nations, and the style of decoration and iconography appears on all sorts of artifacts: house poles, screens, chests, and canoes, and was also used for identifying tattoos among some groups. The symbolic system was coherent. The universe was perceived as a house and the house itself a reflection of the cosmos. For example, the different parts of the house mirrored the human body:

Front posts	Arm bones
Rear posts	Leg bones
Longitudinal beams	Backbone
Rafters	Ribs
Cladding	Skin
Decoration	Tattoos

The inhabitants represented both the spirit of the house itself and the spirit of their ancestors.

Typically carved of red cedar, totem poles usually did not survive in the rain forest climate for longer than a century, and their original meaning was lost as they decayed.

Adinkra

The Akan of Ghana in Africa have an elaborate traditional system of symbols – *adinkra* – which are not only linked to their proverbs, songs, and stories but also serve to affirm social identity and political views. They are universally recognized by the Akan, and have been for many centuries, but to outsiders they appear simply as decorative motifs. The choice of design is therefore an intensely personal statement available even to those who are illiterate. *Adinkra* appear in wood, paint, and metal, but since the Akan are very much a textile culture, they are most prominent in cloth – for example, the handwoven *kente* or the block-printed *adinkra* or 'proverb' cloths. Over 700 symbols with their associations have now been cataloged. Some *adinkra* are traditional – a wooden comb for beauty and feminine qualities – while others have taken on modern meanings, wealth symbols now standing for a BMW or a television. For example, the symbol of the cocoa tree, introduced in the 19th century, and Ghana's principal cash crop, does not simply refer to the plant or to chocolate, but also to its social effects, bitterly expressed in the proverb: '*kookoo see abusua, paepae mogya mu'* – 'cocoa ruins the family, and divides blood relations.' Again, a pattern which a European might 'read' as a daisy, a generic flower, or the sun is a symbol implying unequal opportunity, linked to the proverb: 'All the peppers on the same tree do not ripen simultaneously.'

Adinkrehene
Chief of *adinkra* symbols:
greatness, leadership.

Denkyem
Crocodile:
adaptability.

Duafe
Wooden comb:
beauty, femininity, hygiene.

Dwennimmen
Ram's horns:
strength, humility.

Ese Ne Tekrema
The teeth and the tongue:
friendship.

Funtunfunefu Denkyemfunefu
Crocodiles:
democracy, universality.

Hwemudua
Measuring stick:
inspection, quality control.

Mpatapo
Knot of reconciliation:
peacemaking.

Owo Foro Adobe
Snake climing a raffia tree:
diligence, prudence.

Owuo Atwedee
The ladder of death:
mortality.

Woforo Dua Pa A
When you climb a good tree:
cooperation, support.

Gateways to nowhere

Most monumental architecture – even for religious, ceremonial, or entombment and memorial purposes – has a strong functional element, in addition to its symbolic qualities. A singular exception is the stylized wooden Japanese *O-torii* portal *(below)*, sometimes set as entrances to temples or shrines, which serve to divide the sacred from the profane world. Often freestanding, giving on to nothingness – as is appropriate for Shinto, essentially a nature cult – they are also arranged along paths leading to a shrine.

No one knows the origin of the word – perhaps 'perching place for birds' – but *torii* are traditionally made in three pieces, three being the number sacred to the *kami* or gods. Before passing through the gateway it is traditional to purify oneself by washing at the place provided – *temizu* – and then to bow and clap three times, asking permission to enter the sacred realm. Walking toward the shrine, the center of the path – *seichu* – should be avoided, for that is the walking place of the spirits. These enigmatic gateways are rebuilt on a regular cycle, but of their origin little is known.

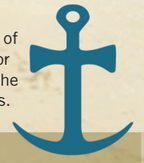
EARLY CHRISTIANS

Christianity in its early years was – literally – an underground sect. Under Rome, it could not declare itself openly, and its adherents adopted secret symbols to express their faith but avoid persecution by the authorities. Many of these coded messages come from funerary remains, especially in catacombs, in Rome and elsewhere, and from Christian secret places of meeting and worship. The faith of the Christian dead was to be declared, but not in such a way that their friends and families would be punished. The cross, now the universally recognized symbol of Christianity, was, however, little used unless disguised. At a time of relentless persecution, it was too dangerous. The first Christians within the Roman empire developed a number of secret signs and symbols, often related to pagan traditions, to identify themselves and each other. These coded messages were fundamental in maintaining the community of belief among members of the early church for several centuries.

The crucifix
The first representation of the crucifixion may be the satirical 'Alexamenos graffito,' found in the remains of a boarding school on the Palatine Hill in Rome. Christ is shown on the cross with an ass's head with a Christian youth praying, and the Greek inscription: "Alexamenos worships (his) God." It has been dated between the 1st and 3rd centuries AD. The cross was thus clearly identified with Christianity at a very early date, but only emerged as the central symbol of the faith in the 5th century.

The disguised cross

The cross was represented by an anchor, a symbol of safety and coming to rest after the storms of life, or sometimes as a trident; the sword as a symbol of the cross was adopted much later, during the Crusades.



Bread and wine

Grain and grapes were symbols of abundance and joy all across the Roman world, where they were dedicated to Demeter, the goddess of the harvest, and Dionysius, the god of wine. The Christians transmuted them into their central mystery – the Eucharist, the bread symbolizing the body and the wine the blood of Christ Himself.

Doves and peacocks

Two further symbols were rooted in the Classical tradition. To the pagan world, the dove was associated with Aphrodite, but for the Christians it represented the Holy Spirit, a pair representing conjugal love, sometimes drinking the water of life from a fountain, while one bearing an olive branch was one of the earliest symbols of reconciliation and peace. Pagans believed peacock's flesh to be incorruptible, and for Christians this was transmuted to represent immortality and the Resurrection.

The chrismon

The cross was often disguised as the chrismon, or Christ's monogram: the two Greek letters *chi rho*. On October 27, 312 these letters changed the Roman world for ever. Two contestants for the Empire, Constantine and Maxentius, were preparing to confront each other at the Milvian Bridge, near Rome. The night before the battle, Constantine had a vision of the *chi rho* blazing against the sky and a voice saying to him "*in hoc signo vinces*" – in this sign thou shalt conquer. Christians in the army told him that it was the emblem of their Redeemer and symbolic of the triumph of life over death. Constantine had the *chi rho* painted on his helmet, his soldiers' shields, and his battle standard. The pagan army had no idea what it meant. Constantine's victory was decisive, and from this date Rome turned towards Christianity. The wreath surrounding the *chi rho* is of palm or bay leaves forming a Roman crown of victory. For Christians, this came to represent the crown of martyrdom.

1ST CENTURY | 2ND CENTURY | 3RD CENTURY | 4TH CENTURY | 5TH CENTURY

Ichthus

One of the earliest symbols was the fish, an ancient symbol of fertility and of life and continuity, or often two fish flanking a trident. Fish and fishermen are frequently mentioned in the Gospels and were associated with the Eucharist, as a reminder of eternal life. 'Fish' in Greek – *ichthus* – was also used as an acrostic:

Iesous	Jesus
CHristos	Christ
THeou	God's
Uios	Son
Soter	the Savior

The simple outline of a fish was often drawn in the sand or spilt wine as a means of secretly acknowledging one's faith.

The five-letter Latin words when read in order (either horizontally or vertically) translate as 'he who works the plow sows the seed.'

The Roman square

A symmetrical arrangement of letters found on the walls of certain Roman houses was probably an ingenious early Christian means of identification. This seemingly innocent proverb can be interpreted as an anagrammatic transposition cipher, the letters being rearranged to reveal a hidden message (*right*). The Latin words *pater noster,* meaning 'Our Father,' form a cross, with the spare As and Os representing the Greek words 'alpha' (beginning) and 'omega' (end), which also have a strong Christian significance.

The 'Good Shepherd'

Depictions of a shepherd with a lamb across his shoulders are found from the 3rd century – Christ guarding and protecting His people – but it was also a favorite Classical motif. A lamb by itself, standing for Christ and His sacrifice, would similarly be understood by fellow Christians.

The Orans

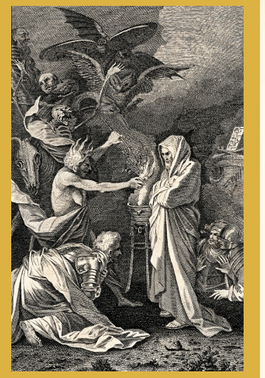
The archaic figure of the person praying with lifted hands was a symbol for humans throwing themselves on the mercy of a divinity and not originally uniquely Christian.

The living crucifix

The first true crucifix is from northern Italy, dated to AD 420. The earliest examples show Christ on the cross but living and triumphant, as on the doors of Santa Sabina in Rome, after the Western tradition wearing a loin cloth to proclaim His humanity; in the east Christ wears a tunic, representing His sovereignty.

NECROMANCY

Strictly, necromancy is the purported practice of communicating with or conjuring the dead for the purpose of extracting information or to predict the future. Beginning in ancient Egypt and Babylonia, necromancy was also widely practiced in Israel, China, and throughout the Greco-Roman world. According to the Christian Church, necromancy amounted to diabolical commerce with unclean spirits, rites of criminal curiosity, and the forbidden invocations of departed souls. But, persisting throughout the Middle Ages, necromancy achieved unprecedented popularity among a clerical underworld who enthusiastically consulted magical grimoires to communicate with subterranean spirits and even angels. Other ancient 'sciences' such as geomancy and theurgy were also avidly studied. Among alchemists and the clergy alike, the notion that specially-coded alphabets and other symbolic devices, derived from their studies of arcane sources, could place humans in contact with the 'other world' became increasingly popular.



Magic in the Bible
Despite the Bible's repeated condemnation of magic, in one peculiar episode King Saul visits a witch from the Canaanite city of Endor and cajoles her into summoning the recently deceased prophet Samuel in order to consult him about the threat of the Philistines. While from the 5th century the orthodoxy of Christian dogma became increasingly set in stone, the possibility of alternative ritual and magical paths to communion with the spirit world held its appeal.

The *Key of Solomon* is one of the most notorious medieval handbooks of magic (attributed to King Solomon himself). The book contains magic circles (*above*), instructions for necromancy, invocations, and binding spells to conjure and constrain infernal spirits.

Ancient origins

Necromancy rituals and ghost expulsion/exorcism texts were commonplace throughout the ancient Near East. In Egypt, as early as the second millennium BC, consultation with deceased royalty was sponsored by the state for public benefit. The central rite usually consisted of the rubbing of magical salves onto the necromancer's face or onto the figurine of the spirit to be consulted. In ancient Turkey, ritual communication with infernal spirits and deities was achieved by means of pits dug into the ground which served as a portal for the chthonic deities to ease their passage between worlds. From this rich bed of mysterious rites, and from the great wave of translations of Arabic magical texts during the 12th and 13th centuries, literate, well-educated members of the European clergy mined necromantic texts which contained a synthesis of astral magic and exorcism techniques combined with Christian and Jewish teachings. The systems of magic depicted in these writings differed radically from the petty sorcery characteristic of the earlier centuries, becoming in effect an erudite method of conjuration and invocation.

Tricks of the trade

The esoteric implements of the medieval necromancer included magic circles, conjurations, sacrifices, swords, and prayer; magical alphabets were also highly significant. Circles were traced on the ground, often accompanied by various mystical symbols drawn from a mixture of Christian and occult ideas. At the opportune time and location, sacrifices and animal offerings were often provided to propitiate ethereal beings. The most important medieval writings on the occult were by the Benedictine abbot Johannes Trithemius (1462-1516, *see page 73*), and his pupil, Heinrich Cornelius Agrippa (1486-1535). The latter's *Three Books About Occult Philosophy* (1531-33) included coded formulae for alchemy, Kabbalism, and the Theban alphabet (*right*), a table for communicating with the spirit world.

Agrippa has often been identified as the model for the priest/sorcerer in Christopher Marlowe's play *Doctor Faustus* (c.1589) who sells his soul to an emissary of the Devil.

The Theban alphabet

Sword
The origin of the magician's wand.

Magic circles
Marked with mystic alphabetic symbols, these provided a sacred space protecting the necromancer.

An imaginative representation of a ceremony to ward off entities from the spirit world. Protected within a magic circle, the necromancers here are protecting themselves from a demon released by their excavations by citing arcane texts, while the central figure transmits the message using a sword.

John Dee

The most famous magician of his age, an astrologer/alchemist/necromancer, and cryptographer, Dr. John Dee (1527-1608) was revered in his time as the most learned man in all Europe. He was the personal astrologer to Queen Elizabeth I of England, and the model for Shakespeare's Prospero in *The Tempest*. He visited many courts in Europe, along with the mountebank Edward Kelley (1555-97), to find funding for his exercises in divination and the occult. It is unsurprising that Dee made many enemies during his time in the court, several of whom continually brought charges of witchcraft against him. Ultimately, Dee would bring about his own downfall: despite his powerful position and prodigious intellect, his occult preoccupations overwhelmed him and he died in extreme poverty in 1608, reviled and pitied as a madman.

John Dee condensed all magic into a single symbolic equation, the occult equivalent of Einstein's $E = mc^2$. In his *Monas Hieroglyphica* he and Edward Kelley produced the Enochian alphabet, a purported means of communicating with the spirit (or angelic) world.

John Dee's single equation

The Enochian alphabet

THE DA VINCI CODE?

The notebooks of the Italian High Renaissance artist and engineer Leonardo da Vinci (1452–1519), which are now divided among several major collections throughout the world, have attracted considerable attention, not least because of their subject matter and his use of apparently coded notes and annotations. The content of the notebooks ranges from sketches from everyday life to anatomical drawings and fantastic weapons of war, and encompasses detailed sketches for artistic commissions as well as mere doodles.

Secret writing

The notes da Vinci wrote on nearly every page of his notebooks appear inscrutable, but are in fact simply in 'mirror writing'; whether this was because he felt the need to disguise his notes from unfriendly eyes, or because, being left-handed, he found it easier to write in this manner, remains a mystery. There is little doubt, however, that da Vinci was concerned that his notes – often for good reason – remained private, or at least obscure to the casual viewer.

Inside the human body

Da Vinci's anatomical investigations undoubtedly involved the flaying and dissection of cadavers, a practice which could have attracted the unwelcome attention of the Church authorities. To modern eyes, his work is informed and authoritative, and certainly the product of practical scientific inquiry.

Life after death
This beautiful rendering of a child in the womb belies the fact that it was only possible as a result of dissection. It is surrounded by da Vinci's observations.

Origins
Da Vinci has added various sketches with commentaries explaining his ideas about the progress of the reproductive cycle from fertilized egg to fetus.

Da Vinci at war

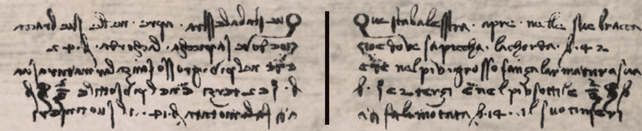
At several times in his career da Vinci was commissioned to design fortifications and develop engines of war for various powerful patrons. While many were eminently practical designs, his fantastical – and often gruesome – imagination produced some very unpleasant machines, and some ingenious devices and flights of fancy (including, indeed, a prototype flying machine).

Killing machine
Da Vinci seems to have been able to separate his compassionate fascination with the workings of the human body from his glee in the deadly efficiency of this fantastic machine.

How does it work?
Da Vinci's text here provides detailed measurements and descriptions of the mechanism which activates the scythes.

Attention to detail
Although it was highly unlikely that the machine would ever be built (or be that effective in the field), da Vinci carefully demonstrated the mechanical workings.

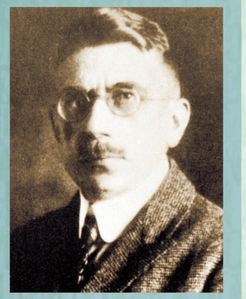
Horsepower
Da Vinci was interested in the science of mechanics and power, and saw the horse as the motor-force which would propel this particular machine into action.



Mirror writing

Although naturally written in classical Italian, da Vinci's elegant hand remains clear, even when written, as it originally was, in reverse (*left*). When photographically transposed (*right*) the accuracy of his writing becomes clear. His secrecy has given rise to numerous far-fetched theories concerning his membership of arcane secret societies – unlikely in a man so interested in investigating the practical properties of the world around him, unlike his contemporary alchemists (*see page 52*).

ENIGMA: The 'unbreakable' system



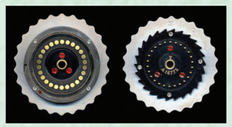
Inventing Enigma
The Enigma machine was first patented in 1918 by Arthur Scherbius (1878-1929) for commercial use, but it soon attracted the attention of the German military. Over the next decade the encoding system was gradually made more sophisticated.

The portability of the Enigma machine was a huge advantage. One is seen here in use on General Heinz Guderian's half-track on the battlefield.

The German military recognized the need for a more secure enciphering system in 1923, after British official histories of World War I revealed that German messages had been read. They eventually acquired over 30,000 Enigma machines, with a more complex design than those available commercially. The Wehrmacht, Luftwaffe, and German Navy all issued separate daycode books throughout World War II. The beauty of the Enigma machine's mechanical enciphering system was that it was very fast and all but eliminated human error – the plaintext was typed in to produce the enciphered text, this was transmitted by radio, and the receiver merely typed in the coded message, and the machine produced the decoded plaintext. In addition, without access to the daycode settings it was almost impregnable.

Reflector
This did not rotate, thus ensuring that encrypted text was automatically sent back through the scrambler disks, mechanically producing the decrypted text as it was typed in.

Scrambler disks
Each contain the 26 letters of the alphabet, and were set in any start position from A-Z (determined by the daycode). They were geared to rotate cyclically. From 1938 the machines had five scrambler disks.



Each disk has 26 contacts on each face (which correspond to letters of the alphabet) wired to 26 different contacts on its opposite face. Each numbered disk would be wired differently.

Plugboard
Originally, you could swap only six letters before the plaintext reached the scramblers, but in 1939, an enlarged plugboard increased this number to ten.

Keyboard
For typing in plaintext (or received encrypted text).

Lampboard
Shows the operator the encryption (or decryption) of each letter when it has been typed in.

The daykey settings

Each month the German military would issue a new daycode book. This listed the individual settings operators were to use each day to set up all Enigma machines within each respective military unit. This ensured that the first message sent could be read by all members of the unit.

Setting up Enigma

Following the daycode setting, every morning the operators would: re-order the scrambler disks; adjust the scrambler orientation (which letter of the alphabet each scrambler should display at the start of the day); and change the plugboard settings. The systems combined meant a total of 10,000,000,000,000,000 calculations would have to be made to analyze the encryption.

Resetting the settings

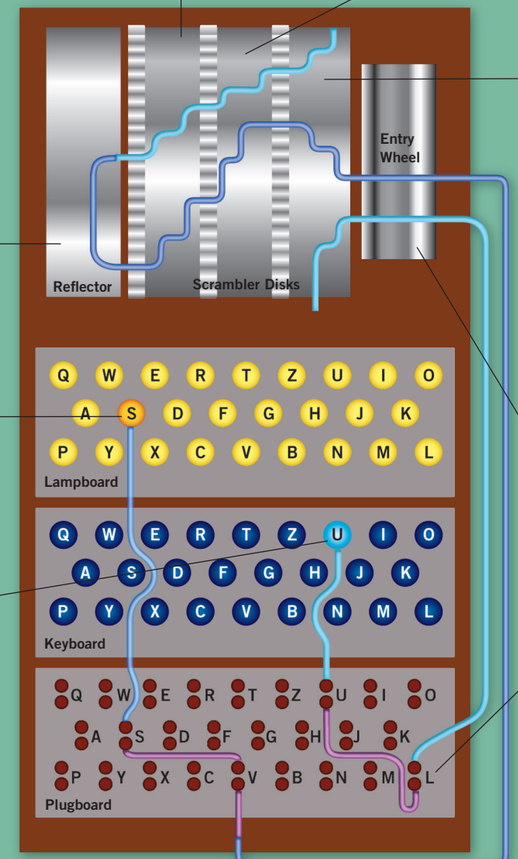
During World War II, in order to increase the level of security, the Enigma operator would send an initial message, using the daycode settings, which would be a new setting for the scramblers. This would be repeated to ensure consistency. Thus, if the daykey required B–M–Q, a second signal might be preceded by a randomly chosen combination of three letters, for example, S–T–P–S–T–P, requiring the receiver to alter his scrambler settings accordingly.

Using the Enigma machine

Plaintext was typed in to produce the enciphered text, this was transmitted by radio, and the receiver merely typed in the coded message, and the machine produced the decoded plaintext.

Encryption

This schematic diagram follows the letter impulse for U, showing its passage to encryption as S. For the purposes of clarity, only four of the available switches on the plugboard have been set.



1 The operator types in plaintext, which is transmitted through the machine by electric current.

2 Letters that have been switched on the plugboard are first enciphered here. Remaining letters go straight to the first scrambler.

3 Passing beyond the plugboard, the letter impulses travel to and enter the first scrambler disk.

4 The arriving letter impulse passes through the disk to a different exit point, and thus a different letter entry point on the next scrambler. In addition, the first scrambler rotates by one notch with every letter that is typed.

5 The process is repeated at the second scrambler which turns one notch (or letter) once the first scrambler has completed its cycle of 26 letters.

6 The process is repeated at the third scrambler which turns one notch (or letter) once the second scrambler has completed its cycle of 26 letters.

7 Each letter impulse now reaches the reflector, which passes it back through the scrambler disks via a different path.

8 The impulse travels back through the plugboard and arrives at the lampboard, where the final encryption is displayed to the operator.

Decryption

Having set the machine using the same daycode settings as the encrypting operator, the receiving operator types in the received encrypted text. The letter impulses pass through the plugboard, the scramblers, and the reflector, and then returns through the system to be displayed, decrypted to plaintext on the lampboard.

Cracking Enigma

Since its introduction by the German military, it had been assumed by everyone that the Enigma system (*see page 116*) was unbreakable. Although versions of the commercial machine had been acquired by Germany's former adversaries, the workings of the military machine and the codebooks were unknown. But, in 1931 the French secret service bought copies of plans of the machine and daycode books from a disaffected German veteran, Hans-Thilo Schmidt, who continued to supply details of the daycode books for several years. The French made little of them. It was Poland that opened the door.

The German challenge

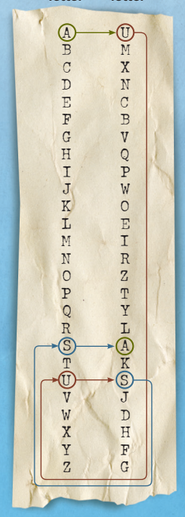
Upon the outbreak of World War II, Allied cryptographers were confronted by an awesome problem. The Enigma system (*see page 116*) had many variations. In addition to its existing complexity, in 1938 the Germans added a further two scrambler disks to many machines, and the plugboard was made more complex. There were also variants on the machines used by different parts of the German military, and each had different codebooks. The Afrika Corps used its own system, as did the *Kriegsmarine*, the German navy. It was the latter's Enigma signals (the Lorenz cipher) that were the most difficult to penetrate and the most vital for Bletchley Park to decrypt, as U-boat activity in the North Atlantic threatened to sever lifeline supplies from North America.

The German addition of two extra scrambler disks meant that their invasion of Poland in September 1939 was a surprise.

Marian Rejewski (1905-80), the man who cracked Enigma.

Poland fights back

In the 1930s, aware of German designs on their territory, the Polish cryptanalytical bureau, Biuro Szyfrów, prioritized breaking the Enigma coding system. An entente with France meant that much of the Enigma material was handed over to the Poles, who set about building replica machines. The Poles realized that Enigma was a mechanical system that required mathematical rather than linguistic skills to analyze. It was an inspired idea. Recent Polish history provided several mathematicians from the formerly German-occupied parts of Poland, who were familiar with the language. Among them was Marian Rejewski.



1 The message key

Rejewski concentrated on the initial Enigma three-letter message key, sent twice at the beginning of each transmission. Realizing that with only three scrambler disks, every fourth letter must represent a different encryption of the first letter, he found a chink in Enigma's armor. He still had no idea of the daykey, but he started to look for links, or chains, of substitution. With access to enough messages in a day, he could build tables of relationships between the first and fourth, second and fifth, third and sixth letters of the message key.

2 Chains

By analyzing these tables he identified chains, that is, how many links there were before the first letter linked back to itself, in this instance A-U, U-S, S-A – three links (*left*). Rejewski realized that, while the plugboard settings were indefinable, the number of links in each chain was a reflection of the scrambler settings. Some chains were long, some short. Rejewski and his colleagues spent a year compiling tables of all the possible 105,456 scrambler settings, correlating them to the length of potential chains. Later, as the Germans changed their protocols, making his tables redundant, Rejewski developed electronic calculators called 'bombes' to recompile the tables.

3 Plugboard

The tables unlocked the scrambler settings, but not the plugboard settings. However, decrypting what they could using the scrambler setting tables, frequently a recognizable message might appear:

SONVOYC ON SOURCE

It is clear that the 's' and the 'c' might have been switched on the plugboard which, when adjusted, would read:

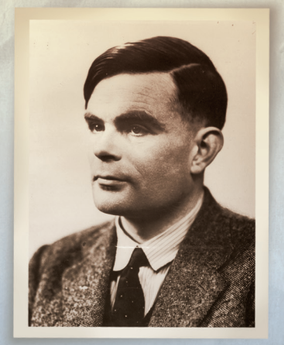
CONVOYS ON COURSE

Success

Rejewski's breakthrough enabled Poland to read Enigma signals for most of the 1930s. The addition of two further scramblers and an extended plugboard in 1938 set them back. A month before the German invasion of Poland in September 1939, the Poles managed to convey two replica Enigma machines, plans for the 'bombes,' and Rejewski's analysis to Britain.

Alan Turing at Bletchley Park

A gifted young mathematician at Cambridge, Alan Turing (1912-54) was among the mixed bag of recruits for the new British cryptanalysis center at Bletchley Park (*see page 118*). He had been working on binary mathematics and theoretically programmable computers and, confronted by what had been achieved in Poland (*left*), he set about designing an improved series of 'bombes' to analyze the newly increased scrambler settings of the Enigma machine. As the Enigma machine settings were altered at midnight every night, they had to work quickly. Nevertheless, the possible settings would be too numerous to work through in the time available without the aid of some further clues, some of which had been identified before Turing arrived in 1939.



Alan Turing, whose 'Turing machines' helped to unravel Enigma.

'Gillies' – Human error and laziness by some Enigma operators led them to use repeated message-key combinations instead of entirely random ones. Once identified these gave the cryptanalysts a useful clue, and signals from those operators were monitored.

Scrambler codes – The Germans assumed that ensuring no scrambler disk occupied the same position on consecutive days would make the system more secure. In fact, it made it weaker, as once one or two of the scrambler positions had been ascertained, it reduced the remaining potential combinations, while also reducing the possible combinations for the following day.

'Cribs' – Identifying known words in a message, a 'crib,' could help unravel the settings. Certain sorts of signal were predictable and formulaic, for example those from weather stations, often beginning with or containing the German word *wetter*. Such signals were monitored, and educated guesses made at identifying words of this sort. Another crib was to lay mines at a specific location, then try to find evidence of the known geographical coordinates in U-boat messages.

'Pinches' – The acquisition of German codebooks was a priority. During the Battle of the Atlantic both U-boats and weather ships were raided, codebooks captured, and the vessels sunk to avoid alerting the Germans to their loss.

Loops – Turing also worked on the problem of what might happen if the Germans stopped repeating the message key. He focused on the archive of decrypts, and began to detect a pattern of 'loops,' not dissimilar to Rejewski's 'chains,' which potentially revealed the scrambler settings if the plaintext was known or a 'crib' guessed. He had discovered another shortcut.

Many machines – If he organized enough 'bombes' working in sequence, each one imitating the action of a different scrambler disk, Turing reckoned he might stand a chance of churning through the 17,576 various possible settings in a short period, but he still required a mechanical shortcut. This he achieved by linking the sequenced machines together, and establishing circuits between them which revealed a matched loop by lighting a bulb on the circuit.

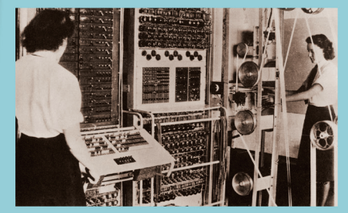
The plugboard problem – Like Rejewski, by setting aside the plugboard problem, Turing had minimized it. With an accurate 'crib' a decrypted word might appear with some odd letters in it which, when transposed, revealed the plugboard settings.

Jumbo and Colossus

Turing's plans for 'bombes' running in series, interconnected, and wired to reveal loops were approved, and £100,000 allocated to create them. Each 'bombe' consisted of 12 sets of replica scramblers, and the first, named 'Victory,' was in operation by March 1940. As the prototype was being tested and improved, the Germans changed their message key protocol, causing a decrypt blackout. An improved 'bombe' was in place by August and, by Spring 1942, 15 more 'bombes' were in place, running through cribs, scrambler settings, and message keys at an industrial rate. On a good day, the system could decipher all these within an hour, revealing the encryption behind the rest of the day's signals. By the end of the war, some 200 'bombes' were in operation. Nevertheless, the entire process still relied on accurate cribs, so human ingenuity still propelled the mechanical system.

Eventually the number of 'bombes' and the links between them created the world's first programmable computer, code-named 'Jumbo,' but known among the operators as 'Heath Robinson.' In 1942 Turing developed a further shortcut for decrypting the German naval Lorenz cipher used in an adapted Enigma machine, the *Geheimschreiber*, and passed on his ideas to Tommy Flowers and Max Newman, who went on to develop the Colossus computer, a more integrated programmable digital device, the true forebear of the modern computer.

In July 1942 Turing traveled to America to share his ideas with US cryptanalysts. Although the British shared their secrets with their Western allies, and Bletchley Park was involved in decrypting Italian and Japanese codes as well, the story of Enigma and its decryption was to remain secret until the 1970s.



Colossus in operation at Bletchley Park.

From Samurai to Yakuza

The *Bushido* code: the Seven Virtues

気 **Courage**

義 **Right Conduct**

仁 **Mercy**

忠 **Loyalty**

譽 **Honor**

礼 **Respect**

信 **Honesty**

These virtues were the keystones of the *samurai* warrior code, (and essentially the same as the US Army 'Core Values' adopted in the mid-1990s). Of many Japanese works on the subject, the best known in the West is the *Bushido Shoshinshu – Code of the Samurai* written by Taira Shigesuke, a *samurai* and military strategist of the early 18th century. It remains an excellent guide to the mindset of modern, and particularly corporate, Japan, and especially the deep-rooted concepts of *giri* – obligation which can extend as far as blood vengeance – and *ninjo* – the ability to feel compassion.

The ideas behind the concept of the *samurai* go back at least 1,000 years in Japan and are based on Confucian ethics, modified for a predominantly martial world. *Bushido* – the Way of the Warrior – was the code by which, ideally, the *samurai* lived and died. The *samurai* formed a powerful and prestigious section of Japanese society for centuries. But, from around 1600, the reforms of the Tokugawa shogunate reduced the opportunities for battle; peace and prosperity led to the rise of merchant classes, and the warriors found themselves increasingly marginalized. Finally, the Meiji reforms of 1868 swept away the feudal world. Many *samurai* were deeply resentful at what they felt was a betrayal of their way of life and the true nature of Japan. Nevertheless, the *samurai* provided a model for several more recent Japanese organizations and institutions, not least the notorious *yakuza*.

A *samurai* helmet displaying the *mon* of the wearer's clan.

The *samurai* were the military elite, retainers of a feudal lord or *daimyo*.

Mon crests

From the 12th century in feudal Japan, identifying crests – *mon or kamon* – were used on the battlefield, on armor, banners, and personal possessions of all kinds. Unlike complicated Western heraldry, each *mon* was generally a single boldly-stylized symbol within a circle; color was irrelevant. The motif might be military, such as arrows, or an animal, such as the butterfly of the Taira clan, but plant motifs were the most common. The eldest son generally inherited his father's *mon*, while younger sons would use a slightly modified variant, so that there are an estimated 10,000 designs registered today. The only crests that were absolutely inviolable were those of the Emperor and his chief advisor. After the Muromachi period (c.1336-1573), *mon* became increasingly common across the social scale and the new merchant class adopted them as advertising logos, which persist today.

Traditional *mon* crests Certain *mon* were reserved for the most powerful in the land.

The inviolable crest of the Emperor

Crest of the Prime Minister

Crest of the Tokugawa shoguns

Crest of the Taira clan

Commercial *mon* logos Many modern Japanese companies still use *mon* as their logo.

Yamaha

Mitsubishi

Toyota

Benihana

The *samurai* legacy

After the modernizing reforms of the 1860s, various organizations invoked the *samurai* past (*below*), among them Genyosha, or Dark Ocean Society, founded in 1881, which aimed to unite hundreds of secret societies, each with their own covert recognition codes. Highly successful and violent, they turned Japan's first election of 1892 into a bloodbath and, in 1895, assassinated the Korean queen, triggering the Japanese invasion that lasted 50 years. The successor to Genyosha was the Kokuryu-kai, or Black Dragon Society, founded in 1901. It promoted Japanese expansion into Asia, and was responsible for acts of violence against student and labor unions, politicians perceived as left-wing, and the democratic process in general. For muscle, they linked up with the gamblers and gangsters of the *yakuza*, which became one of the world's leading crime syndicates. Not traditionally politicized, the *yakuza* also romanticized the *samurai* past, which lent glamor to their occupations of extortion, rackets, prostitution, and people-trafficking.

Right-wing revivalists reveled in the dress and customs of medieval *samurai*.

The *yakuza*

The *yakuza* claim to have an inviolable code of honor (like the Italian Mafia), derived from the *bushido*. Within each *gumi* or gang, loyalties are extremely rigorous, hierarchies – as elsewhere in Japanese society – rigid, and feudal rituals are still observed. The *yakuza* are not, however, a secret society but an accepted part of the Japanese political and business scene – so much so that some headquarters have a plate on the door like any other company. *Yakuza* are easily recognizable, even without the *mon* lapel pins proclaiming their clan affiliation; the clothes, the large cars with darkened windows, the swagger – these are codes for gangsters almost anywhere, but especially in a country where even heads of major corporations are physically self-effacing.

Yakuza traditions

Yakuza are also famous for their spectacular full-body tattoos – *horimono*. These were always associated with the 'floating world,' marking out those living on the margins of society. To be tattooed is a sign of group solidarity and of physical courage, and a declaration of having chosen the dark side. The *samurai* who had disobeyed or failed his lord atoned by *seppuku* – ritual suicide by disembowelment. The modern *yakuza* atones for his offense by cutting off one joint of his finger – *yubitsume*. Initiation rituals and rituals marking agreements are also of great importance, with a certain number of cups of *sake* – an appropriate offering to the Shinto gods revered by the *yakuza* – being formally exchanged. Blood brotherhood rituals involving exchanging blood are now being phased out because of the threat of HIV.

To atone for an offense, a *yakuza* will remove a finger joint, formally presenting it to his *oyabun* ('father').

Each tattoo is individually designed, the motifs including references to the owner's gang and *mon*, and represents hundreds of hours of work. Public baths often have a 'No Tattoos' sign, to the mystification of tourists.

The Zodiac Mystery

The verified murders

A picnic area on Lake Berryessa was the site of the attack on Bryan Hartnell and Cecilia Shepard on September 27, 1969. This artist's impression of the attacker is based on a description by Hartnell, who survived. Although carrying a firearm, the Zodiac used a plastic clothesline to bind them, then stabbed both victims. He inscribed the cross-and-circle symbol on Hartnell's car using a felt pen, and added "Vallejo/12-20-68/7-4-69/Sept 27-69-6:30/ by knife".

Despite the Zodiac's later claims, there remain only five official Zodiac killings. The first occurred on December 20, 1968, when lovers David Arthur Faraday and Betty Lou Jensen were shot on Lake Herman Road, Benicia, California.

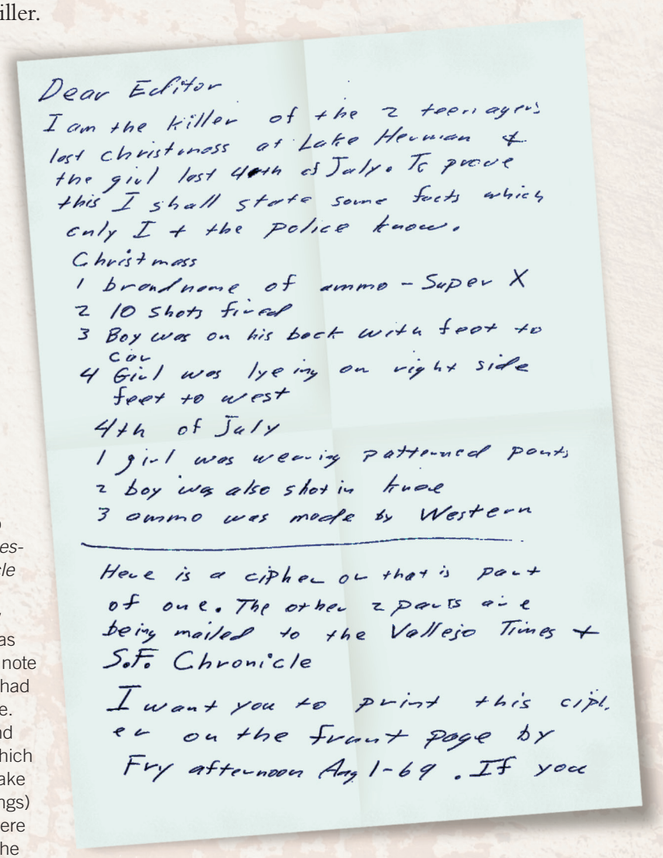
On July 4, 1969 another couple were attacked and shot, at Blue Rock Springs Golf Course outside Vallejo; Darlene Elizabeth Ferrin died, but Michael Renault Mageau survived. This was followed by the Lake Berryessa attack as described above.

Finally, Paul Lee Stine, a cab driver, was shot dead by his passenger on October 11, 1969 at Presidio Heights, San Francisco.

Despite the popular belief that serial killers tend to play cat-and-mouse games with the police, this largely remains the stuff of crime fiction and slasher movies. Very few serial killers want to be caught. While Thomas Harris's Hannibal Lecter might crave public infamy, in reality most try to conceal their tracks. Although the first modern serial killer, Jack the Ripper, did taunt the police with notes and newspaper cuttings, often identifying his victims and supplying appalling details of his crimes, few others have done this. One major exception was the self-named Zodiac killer.

"Dear Editor, I am the killer"

The Zodiac killer stalked the parks and lovers' lanes of the San Francisco Bay and Valley areas, killing five and injuring two in three attacks at remote places between December 1968 and 1969 (although some think he may have struck as early as 1966, and continued until 1974, or later; if all claims – including his – are counted, the body count could be nearer 40). He taunted the authorities with a series of letters and cards, four of which included encoded messages (*see page 142*). The first, and longest, message was sent in three parts to local newspapers – the *Vallejo Times-Herald*, the *San Francisco Chronicle* and the *San Francisco Examiner* – respectively, each received on July 31, 1969. Each coded message was accompanied by a scrawled cover note providing crime scene details that had not been made public by the police. The Zodiac demanded that they and the almost identical cover notes (which claimed credit for fatal attacks at Lake Herman Road and Blue Rock Springs) be published. As a result of this, there was considerable public interest. The police commissioned forensic tests and handwriting analyses in addition to sending the coded notes to cryptanalysts, but few solid clues emerged. However, by August 8, high school teacher Donald Harden and his wife Bettye, readers from Salinas, had cracked the majority of the coded message.

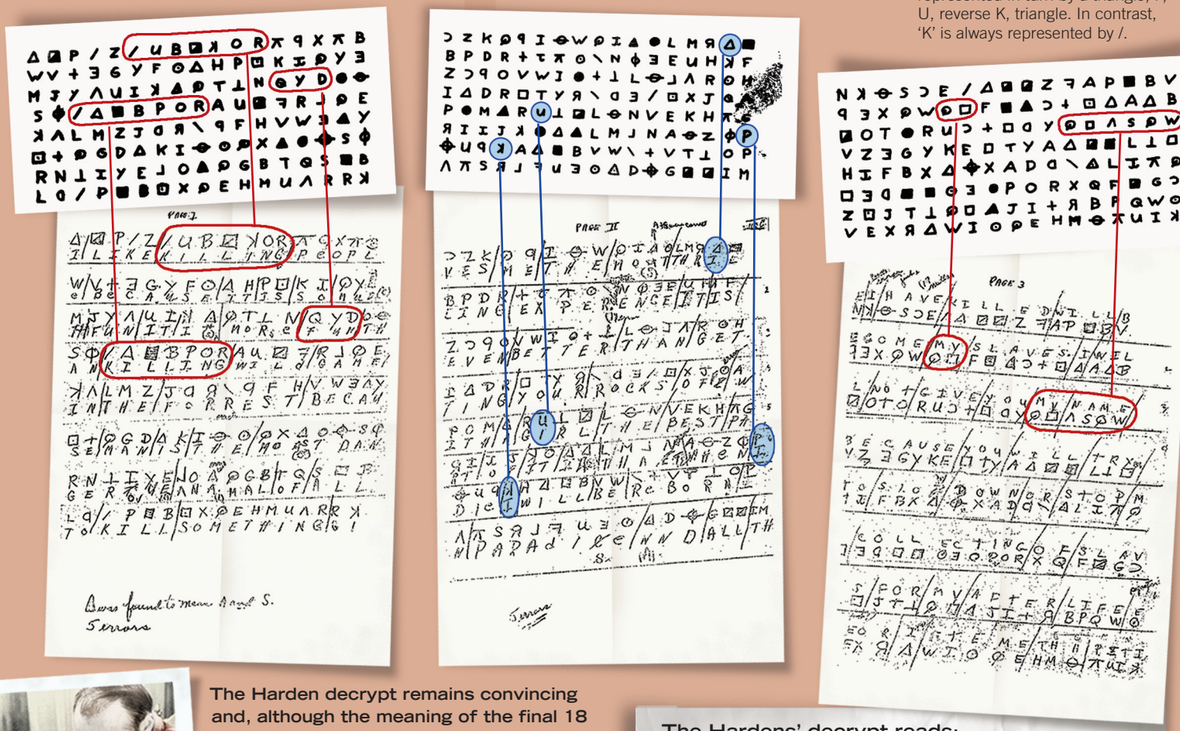

Dear Editor
I am the killer of the 2 teen agers last Christmass at Lake Herman & the girl last 4th of July. To prove this I shall state some facts which only I & the police know.
Christmass
1 brand name of ammo - Super X
2 10 shots fired
3 Boy was on his back with feet to car
4 Girl was lying on right side feet to west
4th of July
1 girl was wearing patterned pants
2 boy was also shot in head
3 ammo was made by Western
Here is a cipher or that is part of one. The other 2 parts are being mailed to the Vallejo Times & S.F. Chronicle
I want you to print this cipher on the front page by Fry afternoon Aug 1-69. If you

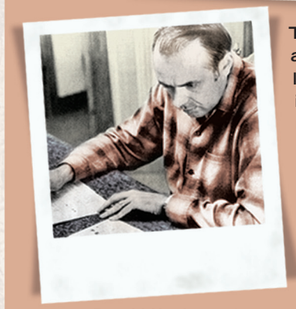
The cover note sent to the *San Francisco Examiner*, accompanying one third of the first coded message. Each cover note revealed unpublished details of the Zodiac's attacks.

The Harden decrypt

The first Zodiac coded message comprised 408 characters organized in 24 rows each of 17 letters or symbols. It was written out on a single sheet of paper, which was then cut into three. This was an idiosyncratic substitution cipher cryptogram, which only partially followed systematic logic, and included misspellings (which may have been intentional). The Hardens assumed words such as 'killing' and 'fun' might appear somewhere, and that the killer 'had an ego,' and that the word 'I' would recur. Frequency analysis also revealed that the Zodiac was using homophones (meaning that certain letters in the plaintext were represented by two or more letters or symbols).

The key words or phrases identified by the Hardens are highlighted in red; having isolated these, the Hardens could begin to flesh out the rest of the decrypt. Some of the misleading homophones are picked out in blue. Interestingly, the key word/letter 'I' was one of them, being represented in turn by a triangle, P, U, reverse K, triangle. In contrast, 'K' is always represented by /.





Donald Harden and his wife Bettye looked for predictable words in the cipher.

The Harden decrypt remains convincing and, although the meaning of the final 18 letters of the message remains unclear, it reveals inherent inconsistencies and misspellings (possibly intentional, as with the cover notes, to give an impression of illiteracy) which provide a chilling insight into the disorganized state of mind of the Zodiac. But the story didn't stop there. While the Hardens had provided a tantalizing glimpse of the inner workings of the Zodiac's mind, his subsequent ciphers and other chilling messages (*see page 142*) proved impregnable, and continue to fascinate cryptanalysts and conspiracy theorists alike.

The Hardens' decrypt reads:

"I LIKE KILLING PEOPLE BECAUSE IT IS SO MUCH FUN IT IS MORE FUN THAN KILLING WILD GAME IN THE FORREST BECAUSE MAN IS THE MOST DANGEROUES ANAMAL OF ALL TO KILL SOMETHING GIVES ME THE MOST THRILLING EXPERENCE IT IS EVEN BETTER THAN GETTING YOUR ROCKS OFF WITH A GIRL THE BEST PART OF IT IS THAT WHEN I DIE I WILL BE REBORN IN PARADICE AND ALL THE I HAVE KILLED WILL BECOME MY SLAVES I WILL NOT GIVE YOU MY NAME BECAUSE YOU WILL TRY TO SLOW DOWN OR STOP MY COLLECTING OF SLAVES FOR MY AFTER LIFE EBEORIETEMETHIPITI"

The Zodiac Legacy

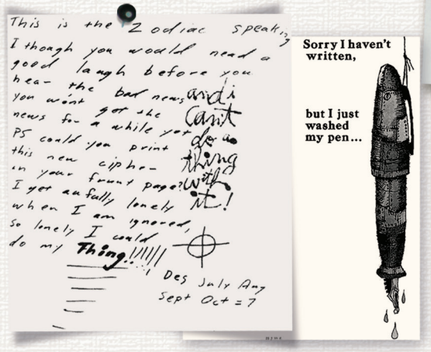
The Zodiac's signature symbol was the most consistent coded image the killer used. Referencing alchemical and necromantic imagery, it also chillingly echoes a telescopic sight.

Despite the Hardens' breakthrough in deciphering the Zodiac's first anonymous cryptogram (*see page 141*), the killings continued, as did his taunts to the authorities (the 'blue pigs' or 'blue meanies' as he called them). Targeting mainly the *San Francisco Chronicle* or its staff, his subsequent 15 or so letters and cards built up a picture of an obsessive not only interested in killing, but in attracting attention by revealing details of his crimes, and ever more monstrous schemes. These mailings included a further three cipher messages which have remained unsolved.

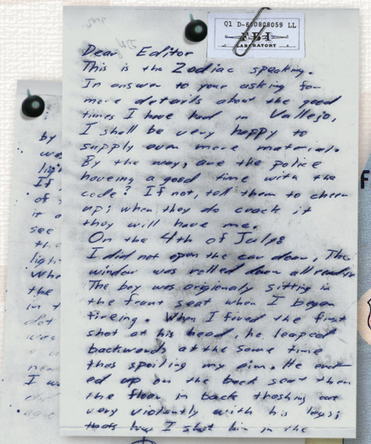
The later letters

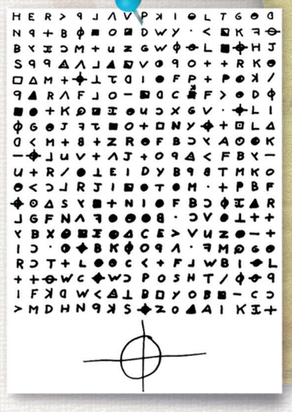
The inclusion of scorecards in his later letters, comparing his claimed body count (ultimately 37) versus the SFPD's success rate (0), reflects a detection success rate as true today as it was over 30 years ago. Several suspects were investigated, but only one remains a strong contender. The fact is that the self-named Zodiac appears to have been active for about two years, and his crimes and subsequent codes remain unsolved.

"This is the Zodiac speaking." The killer revealed his *nom de guerre* in a letter postmarked August 4, 1969 to the *Vallejo Times-Herald*, and for the first time signed the letter with his characteristic cross-and-circle mark.



"Sorry I haven't written." Mailed to the *San Francisco Chronicle* on November 8, 1969, this cheap but sinister novelty card included a 340-character cipher. Superficially similar to his first coded message, the Hardens' decrypting method failed to crack it, and the meaning remains a mystery.

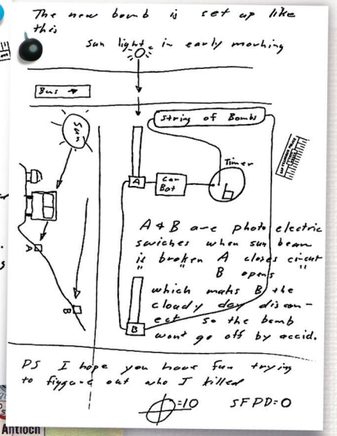




Arthur Leigh Allen in 1969; he remains the most viable suspect in the Zodiac case.

Under suspicion

Popular speculation produced hundreds of possible perpetrators, but only one primary suspect emerged. Arthur Leigh Allen (1933-92) was a loner, who lived at home with his parents, and worked at various elementary schools, among other jobs. Police were alerted by an acquaintance of Allen's in 1971, based on bizarre and incriminating claims by Allen. He was interviewed several times, and the evidence accumulated: forensic techniques were still limited and, despite undoubted similarities, a Department of Justice analysis report in 1971 ruled out any connection between Allen's handwriting and that of the Zodiac. Nevertheless, he behaved erratically and drank heavily; he was known to humorously misspell words and phrases; he possessed guns, and bloodstained knives were found in his car (which he claimed he used for killing chickens); and he admitted reading Richard Connell's 1924 short mystery story *The Most Dangerous Game*, which appears to be referenced in the first coded message. Also, he owned a Zodiac watch, a present from his mother in 1967. Associates and friends provided further intriguing circumstantial evidence. Further, Allen was convicted of child-molesting in 1974. Investigations continued until Allen's death almost two decades later, but the police failed to establish any concrete links.



"My name is ..." The *San Francisco Chronicle* had received a letter postmarked November 9, 1969 describing in detail a plan to bomb a school bus in the Bay Area. Such an attack never materialized (although it later inspired the plot of the 1971 Clint Eastwood film *Dirty Harry*). But some five months later, on April 20, 1970, a further threatened bomb attack was sent to the newspaper, at the end of which the Zodiac included for the first time a scorecard (Zodiac = 10; SFPD = 0). However, included in the letter was an even more explosive piece of information: the Zodiac revealed his name, again in cipher, and again it remains unsolved.

The last cipher The fashion for wearing symbolic badges or buttons temporarily distracted the Zodiac: he realized that his symbol would work just as well as a 'Smiley' or 'Ban the Bomb' logo, and he recognized the horrific celebrity he had acquired. A letter mailed to the *Chronicle* on June 26, 1970 suggests a new fashion in Zodiac buttons. It also included a map (possibly the site of a threatened bomb), a further scorecard, and the fourth and last cipher message which, like the previous two, has never been decrypted.

The Zodiac drops from view Further letters were received by the *Chronicle* postmarked July 24 and July 26, detailing more crimes, but with no further ciphers. *Chronicle* reporter Paul Avery took delivery of an ominous Halloween card mailed on October 27, 1970, but thereafter the Zodiac would seem to have stopped his activities. Two later letters are often included in the Zodiac canon, one postmarked March 13, 1971 to the *Los Angeles Times* threatening a renewed murder campaign targeting LA policemen, and four years later a letter extolling the 'satirical' qualities of 1974 movie *The Exorcist* was received by the *San Francisco Chronicle* postmarked January 29, 1974, but both seem more likely to be 'copycat' mailings and remain unconvincing.

The sample of Allen's handwriting used for analysis. The results were negative.

THE GENETIC CODE

Of all the codes in existence, perhaps the most fundamental is the genetic code. This code, imprinted in the DNA of every organism alive today, contains a list of instructions for how we function and reproduce, not to mention deciding the color of our hair, and if we like brussels sprouts. The organization of each organism's DNA determines whether we are a human, a chimpanzee, or a banana, as well as whether we are at greater risk for heart disease, diabetes, and breast cancer. 'Cracking' this genetic code has been the task of scientists for the past 50 years, so that we may gain insight on similarities we have to other animals, as well as our similarities to each other.

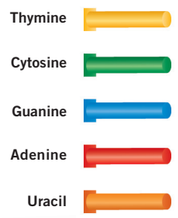
Watson and Crick

Perhaps the two names most associated with DNA are James Watson (*left*, b.1928) and Francis Crick (*right*, 1916-2004). In 1952 both Watson and Crick were researchers at the Cavendish Laboratory at the University of Cambridge with the goal of determining the structure of DNA. In 1952 there was no definitive understanding as to how DNA was structured, organized, or how vital it was in determining our genetic code. Watson and Crick attempted to discover the structure of DNA by playing with scale-model atoms. Soon they discovered how the four bases of adenine, thymine, cytosine, and guanine fit together. They noticed that the molecular structure of each of these bases was such that adenine only fits together with thymine, while cytosine only fits together with guanine. Using this information, they decided to stack these bases on top of each other to see the entire structure. The result was the now-famous 'double helix,' most often compared to a winding staircase. Watson and Crick won the Nobel Prize for their work, together with colleague Maurice Wilkins, in 1962. Though their discovery has been colored by controversy, such as the role of fellow researcher Rosalind Franklin's previous findings, and Watson's statements on race and gender, they are still lauded for bringing to public light the structure and function of DNA.

How the genetic code works

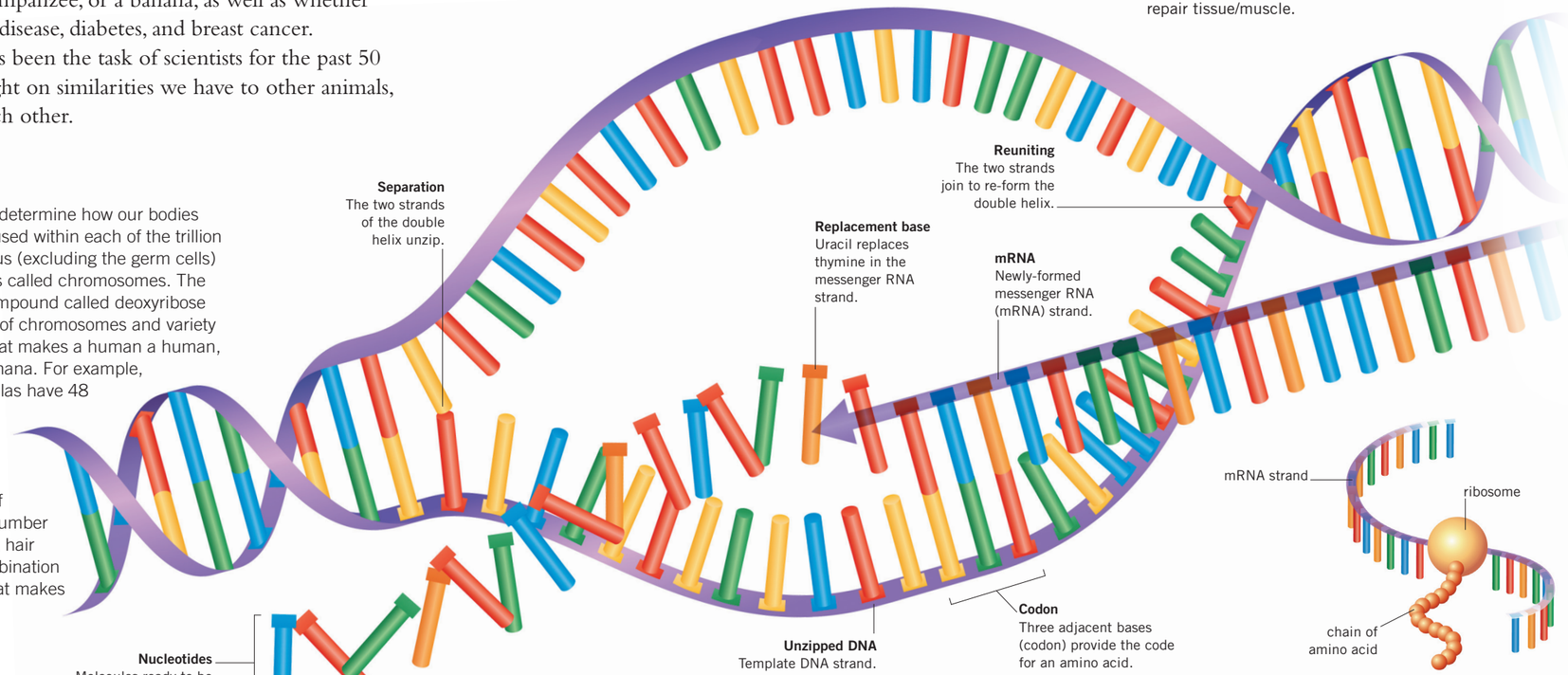
The instructions, or 'blueprints,' that determine how our bodies are constructed and function are housed within each of the trillion cells of our bodies. Each cell's nucleus (excluding the germ cells) contains an identical set of structures called chromosomes. The chromosomes in turn consist of a compound called deoxyribose nucleic acid (DNA). It is the number of chromosomes and variety of genes within each chromosome that makes a human a human, a gorilla a gorilla, and a banana a banana. For example, humans have 46 chromosomes, gorillas have 48 chromosomes, and bananas have 33 chromosomes. Furthermore, although all members of the same species have the same number of genes housed in the same number of chromosomes, many genes have a number of variations (e.g. genes for eye color, hair color, etc.), and it is the specific combination taken from the overall 'gene pool,' that makes each of us a unique being.

DNA is made from four molecules, adenine (A), thymine (T), cytosine (C), and guanine (G) that make up the letters of the DNA code. These four 'bases' are connected to a support structure to form a 'nucleotide' and then strung together to form pairs – adenine with thymine, cytosine with guanine, like the rungs of a ladder. Within the mRNA strand, thymine is replaced by uracil.

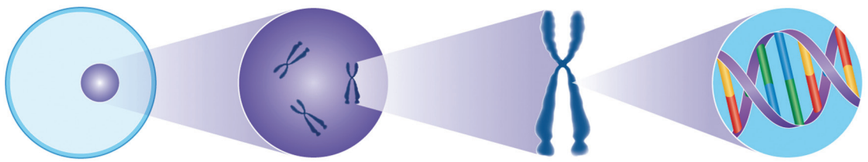


Genes and proteins

Living things break down nutrients into their constituent parts and synthesize what they need according to the template supplied by their genes. A gene is a length of the DNA strand containing anything from 500 to 10,000 base pairs that provide the code for an individual protein. The order of the base pairs within the genes forms a 'template' or 'code' that determines how the proteins of our body are manufactured, the primary task of genes. Proteins are constantly being produced in order to regulate our bodies' functions and build or repair tissue/muscle.

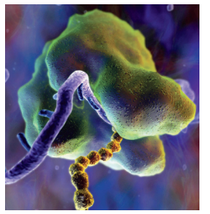


Chromosomes are made from DNA found in the nucleus of living cells.The double helix structure of DNA contains the blueprint for life.



Transcribing the code When genes are being read, the two sides of a section of DNA 'unzip.' One of the DNA strands acts as a template. Nucleotides align themselves sequentially by base-pairing along the 'template' strand, forming a 'messenger' RNA (mRNA) strand. The sequence of bases on the new mRNA strand thus matches the sequence on the DNA strand that was previously paired with the template (with the exception that RNA uses a base called 'uracil' instead of thymine to pair with adenine). This process is called 'transcription.' The newly-formed strand of mRNA detaches and migrates out of the nucleus to a cellular structure called the 'endoplasmic reticulum,' which is the site of protein synthesis.

Translating the code Proteins are essentially long chains of molecules called amino acids. Only 20 types of amino acid exist. Each amino acid is specified for by three adjacent bases (called a 'codon') on the mRNA strand. There are four different bases so 64 different codons are possible. During protein synthesis a cellular organelle, called a 'ribosome,' works its way along the strand reading or 'translating' the codons. Another type of RNA molecule, transfer RNA (tRNA), attaches to the required amino acid and delivers them to the ribosome where the protein is built up, amino acid by amino acid, according to the code originally inscribed in the DNA.



A ribosome reading along an mRNA strand, attaching amino acids to each other to build a protein.

Humans and our closest relatives

One of the most important pieces of information we can learn from studying the genetic code is how humans are related to our closest animal relatives. A comparison of human *(above left)* and chimpanzee skulls *(above right)* suggests marked similarities, but many differences. In fact, comparisons of our genetic code to that of chimpanzees, for example, has shown that we share approximately 98.5% of our genes, and that it is only the 1.5% difference between us and chimps that makes us human. In addition to discovering how closely related humans are to our closest relatives, genetics studies can also determine the approximate date of the most recent common ancestor between humans and any number of animal relatives. This information can be extremely useful as a complement to fossil or archaeological information. Research in this area has revealed that the most recent common ancestor between chimps and humans was approximately 5-7 million years ago, a date that is also supported by fossil data on the earliest human ancestors.

BODY LANGUAGE

Aside from verbal communication, the potential for determining or demonstrating moods and feelings by the manipulation of the face and body is huge. Alongside self-conscious use of body language such as winking, frowning, or waving, careful observation can reveal a complex of hidden – and often unintended – subconscious messages. An enormous amount of such information is instinctively understood – we can normally tell if someone is interested or bored by us, if they are embarrassed, or if they have 'something to hide.' The science of decoding what individuals reveal about themselves is now widely understood by psychiatrists and psychoanalysts, and this knowledge is used in personnel recruitment, interviews, and interrogation.

Body in control

While most of us strive to control the messages our bodies might be sending out, some reactions often prove uncontrollable. Blushing, perspiring, weeping, and reacting to pain often cannot be contained. The eye can give away many signals, the dilated pupil frequently indicating interest or attraction, while an inability to make or maintain eye contact usually means embarrassment or dishonesty.

Making faces

Artists from classical times onwards observed and sketched facial expressions and physical stances and poses as a means of expressing emotions in their work. However, the Austrian portrait sculptor Franz Xaver Messerschmidt (1736-83) was one of the first to attempt to catalog the range of human expression in a series of over 50 busts, based on studies made in lunatic asylums in Munich. Although often extreme, these studies reflect the Enlightenment's interest in every aspect of human behavior.

Conscious and subconscious communication

If we divide body language into two areas, facial expressions and posture or gestures, it becomes clear that we are much more conscious of many of our facial expressions rather than ways in which our bodies can show how we are feeling. We are much more aware of smiles, grimaces, frowns, and shocked expressions, although by adulthood the brain is so conditioned that these can be difficult to control. Much can also be read from hand and arm movements which are, in the majority, subconscious gestures that enhance and reflect the speaker's attitude toward the topic of conversation, considerably more commonplace among speakers of Romance languages such as Spanish or Italian.

Examples of more subconscious body language

Legs and arms firmly crossed Disinterest, annoyance, a defensive posture.
Leaning forward, hands to chin Attentive, interested, enthusiastic.
Playing with tie or hair (men) Nervous, uncertain.
Comfortably crossed legs, bouncing of the foot (women) Flirtatious invitation/sexual interest.
Eyes looking to left Obvious discomfort, often lying, bad in interviews.
Eyes looking to right Fact-finding, consideration, fine in interviews.
Head up, blank eyes Mild interest, perhaps thinking of something else.
Head tilted to one side, narrowed eyes Interest, positive consideration.
Tightening of the jaw/clenching teeth Frustration and anger.

Poker 'tells'

Poker is as much a game of skill as it is the chance fall of cards. Much of that skill resides in the ability to conceal one's own emotions during a game, and to 'read' what is going on in the mind of your opponents. Giveaway signs are known as 'tells.' In the movie *Casino Royale* (2006), James Bond uses his expert intuition to recognize when the criminal mastermind 'Le Chiffre' is bluffing – he blinks. When Le Chiffre knows his hand is awful, he really gives the game away by bleeding from one eye. Here are a few, more subtle, tells from the gaming tables.

Hand shakes
Look out for shaking hands when betting. Among new players this normally indicates they have a good hand, and are excited at the prospect of winning. Equally it may indicate a bluff.

Eyes down
Glancing at their chips just after the deal is complete (the 'flop') usually means a player has hit their hand. In contrast, staring at the 'flop' – searching for something – often means they missed. It may indicate a forthcoming bluff. Many professionals now wear sunglasses to conceal these tells.

Frozen time
Signs of increased tension: gum-chewers will often stop chewing when they bluff; similarly a person may momentarily stop breathing when making their play.

Talk the talk
With a strong hand players tend to be confident, talkative, and relaxed. Agitated behavior or forced conversation may indicate weakness.

I'm in
An eagerness to bet can reveal a lot. Players holding a strong hand are usually keen to get their bet in the pot. A key tell here is the player who usually waits, biding his time before calling, and then uncharacteristically bets quickly. However, taking some time to bet can conceal many ruses, and can unsettle the rest of the players.

Flirtatious fans

In 19th-century Spain, wealthy young ladies would always be accompanied by a chaperone outside the house. These chaperones were famously zealous, and were charged with overseeing the behavior of their young ladies, and ensuring that they were brought up in an honorable manner. Conversation with young men that strayed from virtuous subjects such as the weather, art, literature, and politics was forbidden, forcing the maidens to create their own means of communicating using their fans. A catalog of gestures developed, designed for covert courting and flirtation. Of course much of this was intuitive, but late 19th-century fan manufacturers began to publish 'guides' to fan language, partly perhaps to increase sales.

Moving the fan slowly over the chest I am single.
Moving the fan quickly in snappy movements over the chest I have a boyfriend or partner.
Opening and closing the fan, then touching the cheek I like you.
Touching the temple with the fan and looking skywards I think of you day and night.
Touching the tip of the nose with the fan Something doesn't smell good here (the man is displeasing her, perhaps by flirting with someone else).
Walking sideways, hitting the palm of the hand with the fan Careful, my chaperone is coming.
Opening and closing the fan then pointing with it Wait for me there, I'll be there soon.
Covering the mouth with the fan and looking suggestive Sending a kiss.
Carrying the fan closed and dangling from left hand I'm looking for a boyfriend.
Fanning very rapidly I'm not so sure about you ...
Closing the fan very rapidly Talk to my father ...
Placing the fan closed over the heart I love you very much.
Placing the fan open over the heart I want to marry you.
Giving the fan to the man My heart belongs to you.
Taking the fan from the man I want no more from you.
Covering part of the face with the open fan We've finished.
Letting the fan drop I'm suffering but I love you.
Hitting the left hand with the fan I like you.
Looking outside I'm considering it ...
Hitting right hand with fan I hate you.
Hitting dress with the fan I'm jealous.
Resting the fan closed on the left cheek I'm yours.

The Language of Dreams

Everybody dreams: dreaming is part of our sleep process, whether or not we actually remember them on waking. In ancient and modern cultures alike, we have always been fascinated by our dreams – or more precisely, fascinated by what our dreams could mean or tell us. Dreams as prophecy, dreams sent by a higher power, dreams as the key to the unconscious, dreams as a means of healing, dreams as completely random permutations of our thoughts; different people at different points in history have believed that dreams are all these things. This cacophony of different ideas means there can be no all-encompassing dictionary for the language of dreams, although there have been many attempts.

Dream temples

In ancient Greece, temples dedicated to Asclepius the god of medicine were called *asclepieia*; they were essentially places of healing where people went to be cured. To begin the healing process, a would-be patient spent a night in the temple, and the next day would tell a priest what he or she had dreamed; the priest would then interpret the dream and base his prescribed cure on what the dream revealed. The language of dreams for followers of Asclepius was an essential guide to treating illness. Such reliance on the interpretation of the symbolism of dreams is widespread in many cultures across the world.

> "The interpretation of dreams is the royal road to a knowledge of the unconscious activities of the mind."
>
> SIGMUND FREUD, *THE INTERPRETATION OF DREAMS*, 1900.

Down the rabbit hole

The significance of dreams is shown by how often dreams and the act of dreaming feature in works of art throughout history; dreams and their interpretation are important in both the Old and New Testament (Joseph as a dreamer and interpreter of dreams in Genesis, and Pilate's wife's dream in Matthew) and in classical works such as Homer's *Iliad* and Ovid's *Metamorphoses*, while the Roman emperor Constantine attributed his conversion to Christianity to a dream (*see page 43*). As a result, the dream poem was an extremely popular form in medieval Europe, notably in Geoffrey Chaucer's *Book of the Duchess*, Dante's *Divine Comedy*, and the *Hypnerotomachia Poliphili*, although such dream poems often served an allegorical purpose. Later writers have written in dream form, as, for example, Lewis Carroll's *Alice's Adventures in Wonderland* (1865).

Alice's adventures are presented as a dream narrative, combining surreal imagery with an underlying logic often derived from the author's experience as a mathematician.

The psychology of dreams

Freud theorized that dreams could be interpreted; each individual has their own 'key' to decoding the language of their dreams and therefore their unconscious. Freud believed that ultimately all dreams are unconscious wish-fulfillments, although their representation of an unfulfilled wish may be strange and obscure; he believed the same was true of any kind of dream – including daydreams. Jung attached greater significance to dreams and dreaming than Freud; like Freud, he saw them as outlets for our unconscious, but not merely as a key to the unconscious. He believed that dreams had their own internal language and logic and, for the more spiritual Jung, the unconscious world of dreams was as important as our waking life.

Living life through dreams

One particularly perplexing aspect of dreaming is our participation in unsettling activities, which both Freud and Jung recognized as the expression of suppressed desires or anxieties. Some dream activities or situations recur frequently enough to be tentatively identified:

Dancing Meant to signify good luck.

Flying To fly high forewarns of marital difficulties; to fly low symbolizes illness; falling forewarns of a downturn in luck, but waking before hitting the ground is a good sign.

Nudity Dreaming of being naked is a sign of looming scandal in your life.

Swimming Generally a positive omen; if you find yourself sinking, this forewarns of a struggle ahead; swimming underwater foresees worry and difficulties in your life.

Teeth Dreaming about loose teeth is an unlucky omen; if your teeth are knocked out, this forewarns of sudden disaster; examining your teeth is a warning that you must make sure your affairs are in order.

Animal dream symbols

The appearance of departed relatives or long-lost friends, often remembered in convincing detail, is not difficult to interpret, if unsettling upon waking. However, the appearance of animals has invited some speculation, although most cultures interestingly concur as to their significance.

Bees A positive premonition; bees symbolize a fertile, successful, and happy life for the dreamer.

Cats This can spell misfortune; black cats are associated with bad luck and dark forces; white cats indicate hard times ahead.

Crocodiles Indicate a hidden danger in the future of the dreamer.

Dogs A dead or dying dog may forewarn of the death of a good friend. Otherwise faithfulness.

Horses A black horse indicates mystery, and possibly the occult; a white horse represents prosperity and good fortune.

Lions Presage influential and prosperous friends who will assist you in the future.

Owls If you kill an owl or see a dead one in a dream, you will survive a dangerous experience.

Whales Symbols of good luck.

The Nightmare (1781) by Henry Fuseli shows a sleeping woman surmounted by an incubus, a male demon believed to visit and assault women when they sleep, with his steed, the 'nightmare.'

The science of Surrealism

There is no set 'text' for codifying the imagery that our brains conjure up when we are asleep, but dreams inspired visionary Romantic artists such as Henry Fuseli, Goya, and William Blake. In the 20th century the Surrealist movement produced artists Salvador Dalí (*above*), René Magritte, and Joan Miró, who appear to have instinctively identified a 'language' of dreams with which most of us can identify. The more literary Surrealists experimented with 'automatic writing' which often involved associative game playing, juxtaposing one word image with an automatically triggered response, supposedly revealing some sort of hidden unconscious 'truth' or 'meaning.' The American Beat writer William S. Burroughs meticulously recorded his (often drug-induced) dreams, and used his notes as a compositional device, notoriously in *The Naked Lunch* (1959), before exploring the 'cut-up' method of randomly assembling snippets of texts to provoke an 'automatic' but poetic reaction in the reader. The Surrealists were very impressed by cinema's dream-like editing, a technique used by film directors such as Luis Buñuel, Federico Fellini, and David Lynch to evoke convincing dreamscapes.

Un Chien Andalou (1928), an exercise in Surrealist filmmaking by Salvador Dalí and Luis Buñuel, paraded a number of nightmare dream sequences.

DOOMSDAY CODES

It has many names: Doomsday, Armageddon, the Apocalypse, Judgment Day. Throughout history people of many religions, from many societies, have believed that they were living at the 'end of days,' that there were only 'minutes to midnight.' In the last 50 years, more than ever we believe the end of days is looming: nuclear holocaust, environmental disaster, global pandemic, World War III – these are popular ways to end the world in the media. Many fringe groups and paranoid individuals believe the Apocalypse is nigh, and moreover that it has been predicted already; they believe that if we can crack the right code, we will see it for ourselves.

The Four Horsemen
The medieval fear of War, Conquest, Pestilence, and Death (as in the Albrecht Dürer print, *above*) remains with us. A strange mixture of astronomical, astrological, and other calculations have produced an enormous number of 'doomsdays.' Nostradamus postulated that the most inauspicious dates for the human future would appear when:
Good Friday fell on April 23, St. George's Day;
Easter Day fell on April 25, St. Mark's Day;
Corpus Christi fell on June 24, St. John the Baptist's Day.
This has occurred in the following years, and some calamitous events have been attributed to the 'coded' calculations of Nostradamus:
AD 45, 140, 387, 482, 577, 672, 919, 1014, 1109, 1204, 1421,1451, 1546, 1666, 1734, 1886, 1945. The next dates to beware of are 2012 and 2096.

Nostradamus

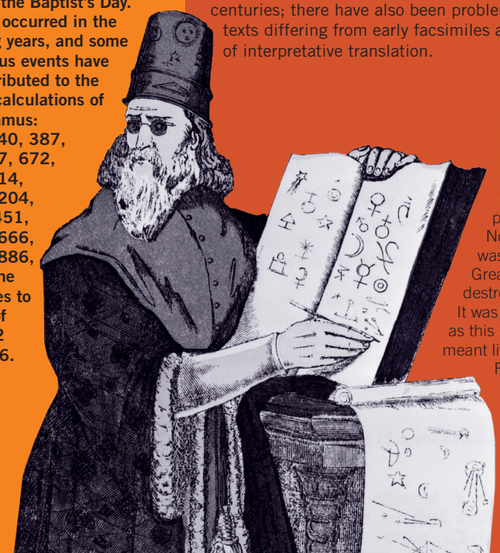
Born Michel de Nostredame, the Frenchman Nostradamus (1503-66) was one of the leading astrologers and physicians of the Renaissance. During his lifetime, Nostradamus made some 6,338 predictions in his best-selling annual publications of 'almanachs,' 'presages,' and 'prognostications'; in recent years, people have been most interested in his 'perceptual prophecies' that are thought to foretell world history up until AD 3737. People have linked these prophecies to events as diverse as the rise of Hitler and the Kennedy family in the USA, and have used these apparently 'fulfilled' prophecies as evidence that Nostradamus was a genuine prophet. Many myths and rumors surround Nostradamus – for instance that he was buried upright with a medallion round his neck predicting when he would be dug up – and there are many problems with his prophecies. Some believe they were written in code, but in fact the order of books such as *Les Centuries* have just become scrambled texts, corrupted over the centuries; there have also been problems with copied texts differing from early facsimiles and the problem of interpretative translation.


ESTANT aſsis de nuit ſe-
cret eſtude,
Seul repouſé ſus la ſelle d'æ
rain,
Flambe exigue ſortant de
ſolitude,
Fait proferer qui n'eſt à croire vain.

The first 'Century' quatrain
Being seated by night in secret study,
Alone resting on the brass stool:
A slight flame coming forth from the solitude,
That which is not believed in vain is uttered.

Archaic spelling
Probably originally written in Low Latin, the quatrains have been translated into French; about five percent of the terms are not recognizably French, and another five percent are Old French, Greek, or Latin.

As was typical in 16th-century literature and writing of all kinds – even in what we would term scientific writings – Nostradamus wrote in quatrains (four-line verse), using flowery and poetic language, and deliberately used obscure Greek and Latin vocabulary; although to the uneducated this might seem like 'code,' in fact it is just metaphor, presumably to keep his predictions ambiguous enough not to upset any people of influence.



Among the dangerous dates predicted by Nostradamus (*left*) was 1666, when the Great Fire of London destroyed the city (*right*). It was synchronicities such as this (which nevertheless meant little to a peasant in France or China) that have provided an element of credence for millennialists.

Minutes to midnight?

The Doomsday Clock is the creation of the *Bulletin of the Atomic Scientists* at the University of Chicago; since its inception in 1947, it has been regularly maintained by its creators. Its purpose is mainly symbolic as it is supposed to represent the changes and developments in science and technology that are pushing civilization closer to the End; the positioning of the hands of the clock's face represents how close to 'midnight' civilization currently is. The clock's maintainers take into consideration the potential of political, economic, and environmental influences on impending doom such as nuclear war, global warming, and the development of biotechnology: the clock stood at one minute to midnight in 1953 (the USA and the Soviet Union had tested nuclear weaponry within nine months of each other), and in 1984, in the midst of the Cold War. As of January 7, 2007, the clock stood at five minutes to midnight.

Apocalypse averted

Y2K, the 'year 2000 problem,' or the 'millennium bug,' was the fear that the timing systems programmed into computers around the world would not be able to handle the rollover into the third millennium AD, and that the effects of this would be potentially disastrous on a world that relies so heavily on computer technology. Would we lose control of our nuclear power stations...our hospitals...our weaponry? The problem stemmed from the programming design of early computers that, it was believed, would cause date-related processing to become defective between and after December 31, 1999 and January 1, 2000. Many governments and private companies invested hugely in upgrading computers to make sure they were 'Y2K-safe.' In fact, not much happened on December 31,1999, either in countries that spent a lot of time and money to insure their computers were Y2K compatible, or in countries that did not. In Australia, the worst did happen: in two states, bus-ticket validation machines stopped working, but luckily nobody died.

2012: 'The End of Days'?

December 21, 2012 has been cited by many New Age followers as the date for a cataclysmic event that will either end or change human civilization forever. Some base their theory on the Mesoamerican Long Count Calendar (*above*) used by the Maya that dates back to 1800 BC; this measures dates over long periods of time (anything longer than 52 years) and the winter of 2012 is at the end of the 5,125-year cycle the calendar covers. This date coincides with the 'Galactic Alignment,' the alignment of the solstice Sun with the equator of our galaxy, the Milky Way, and is further used by some New Age believers to support their theories. Oddly, it coincides with one of Nostradamus' apocalyptic dates (*opposite*). However, academic Mayan specialists dismiss these ideas, saying there is no reason to believe the end of the Long Count Calendar signifies the end of the world (the world certainly existed before the beginning of the calendar) or even to believe that the Maya intended it to.

Future Medicine

Many of us today encounter medical techniques unheard of when we were born, such as 'keyhole' surgery, and routine organ transplants. The speed of medical research, especially with the completion of the Human Genome Project (*see page 174*), coincided with other developing technologies, not least pharmaceutical research, but also miniaturization (nanotechnology) and robotics. All of these to some extent depend nowadays on coded computerized technology. In the half century since Watson and Crick identified the DNA code (*see page 170*), our well-being and longevity, for good or ill, rely increasingly on digital technology.

The Hippocratic Oath

This venerated code of conduct among doctors worldwide was originated by the clinical physician Hippocrates of Cos (c.460-c.370 BC), whose ideas were recorded by others in the *Corpus*. Across the centuries, in its essentials the code enshrines four main moral precepts:

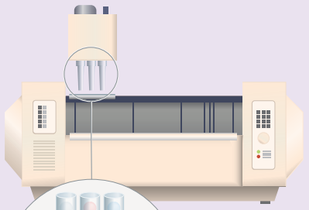
Tradition The veneration of one's teachers, and a commitment to pass on knowledge to the next generation.
Sanctity of life To offer the best possible medical advice to the patient, and to refuse to give a patient poison if requested (originally extending to refuse to administer abortificants).
Patient confidentiality To never pass on to a third party details of a patient's condition without their consent.
Respect To avoid intimacy with patients.

Physicians today are, however, confronted by an increasing number of challenges as society and scientific research evolves. Abortion on demand remains a heated social, ethical, and often legal issue; arguments for voluntary euthanasia in cases of extreme distress are counterbalanced by moral issues and clinical advances; the problem of innovations in identifying genetic heritage are discomfiting, while genetic engineering, especially in the human sphere, remains an enormously controversial issue for the medical profession.

New technologies

The advent of computerization has transformed medical science to the extent that machines such as modified ink-jet printers are now being used to 'build' replacement body tissues while computerized analysis of functions such as sight and hearing among animals are helping to reconstruct damaged systems for the human blind and deaf. On the other hand, DNA-related experiments have shown that rebuilding lost body parts is no longer science fiction, but will soon be science fact.

The da Vinci robot A current robotic surgery suite used increasingly for delicate, minimally invasive surgery. Advantages include greater precision, greater range of movement, and 3-D vision via miniature cameras inserted into the body. Although essentially controlled by surgeons, increasing autonomy is being given to the robots as a fail-safe against surgeon error.



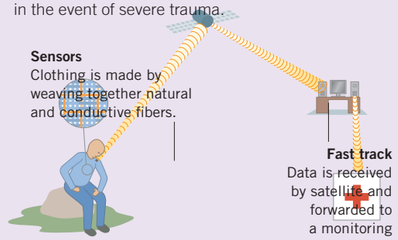
Organ printing Modified ink-jet printers are already in development that may print living tissues and organs, using a support gel for paper and living cell cultures as ink. The cell cultures could be grown from an individual's own cells providing organs that will not be rejected, bypassing the need to find a matching donor.

Printing
Inks made from different cell types are printed onto a support gel.

Ready to use
The cells merge as the support gel relaxes, forming the final tissue. Complete organs could be printed in this manner.

3-D structures
Alternate layers of cells and support gel are built up.

Wearable sensor clothing
Clothing patches can monitor health functions, such as pulse, conductivity, breathing rate, and electrolyte levels in the sweat. They will be able to communicate directly with health centers, giving the medical status and whereabouts of the wearer. This data may be used for general health information and emergency service call-out in the event of severe trauma.

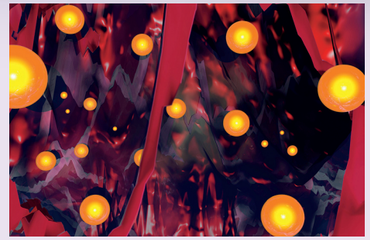


Sensors
Clothing is made by weaving together natural and conductive fibers.

Fast track
Data is received by satellite and forwarded to a monitoring station.

Data collection
An in-built processor collects and sends data to satellite.

Vital signs
These are assessed and in case of emergency a medical station is notified and assistance immediately dispatched.



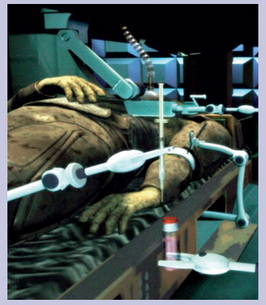
Nanotechnology At the nanoscale (one billionth to 100 billionths of a meter) treatments are being developed that could one day become commonplace. Minuscule molecular balls called 'nanoshells' or 'buckyballs' are beginning to be used to deliver drugs and other therapies to specific sites in the body – particularly useful for the delivery of chemotherapy drugs direct to cancer cells, avoiding normal cells and thereby minimizing side effects. Supports built from nanotubes called 'nanoscaffolds' will help provide a structure for regrowth of damaged tissue such as nerve tissue and as a base for the regrowth of organs.

Decoding brainwaves Signals picked up by electrodes inserted into a cat's brain have already been used to recreate hazy images of its visual field. The signals, taken from a point just behind the optic nerve, were interpreted using 'linear decoding technology.' Working in reverse, it may be possible to translate images from a camera into signals that can be fed directly to a person's visual cortex, allowing a blind person to see. Today, algorithms are being researched that can mathematically model the activity of the visual cortex. Ultimately, this may lead to 'seeing' someone else's dreams and imaginings.

Battlefield medicine

Throughout history, the need to treat soldiers injured in battle has provided countless medical breakthroughs. In the future, mobile, robotic surgical units may be deployed to retrieve fallen soldiers and stabilize them prior to evacuation. Named 'trauma pods' after similar machines imagined by Robert Heinlein in his 1957 sci-fi book *Starship Troopers*, these units would provide automatic care during the 'golden hour' (the first hour after injury), crucial to the fate of the injured soldier. Other advances may include regenerative techniques such as spray-on skin to treat burns, blood clot-forming powder, and field dressings chemically impregnated to stop blood loss (the cause of 50% of deaths on the battlefield). These advances are already in limited use.

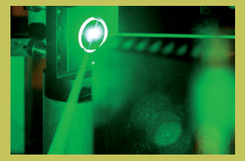
Small portable anaesthetic devices that shut down pain signals coming from injured regions of the body are also being developed. Ultrasound devices are envisioned that will locate and cauterize internal wounds. Externally, battlefield clothing may remotely inform medics of a soldier's physical status. This early triage will mean the most severely injured will be treated first.



Inside the 'trauma pod' An injured soldier is medically assessed and stabilized robotically prior to evacuation.

Where are codes taking us?

Our finesse in finding coded languages to describe the world and manipulating the results is astounding, yet many believe that the 'digital revolution' has barely begun. Computing power is doubling roughly every two years, according to Moore's Law (*see page 272*), as are improvements in many other aspects of digital technology. Phones, cameras, cars, music systems, televisions, and above all PCs have changed so radically in the last few decades that were we to step back just 20 years their antecedents would seem unfamiliar, if not quaint. Is there a limit to this progress? There are certainly limits to the number of transistors that can be fitted on a silicon wafer. These have formed the basis of microprocessors and thereby computing power for several decades, but overheating and finite size both impose constraints that are increasingly difficult to overcome. Time for something new.



Quantum computers

The most promising research involves harnessing the potential of subatomic particles and the world of quantum physics. When things are very, very small (the size of atoms and subatomic particles), the physical laws that govern them change radically. This is the realm of quantum physics, where particles are also waves, and matter is energy. Researchers are finding ways to exploit this particle/wave duality to build computers with a vast increase in storage capacity and processing speed to solve problems in seconds that would currently take hundreds of years, but there are many problems yet to be overcome in building fully-functioning quantum computers. One quantum effect called 'entanglement,' referred to by Einstein as "spooky action at a distance," has been used to 'teleport' quantum information. This has implications for both quantum computation and data encryption, and will allow for completely secure transfer of data.

The DNA connection

Research into new types of computer points to a future of near infinite computing power and capacity at speeds unheard even with today's supercomputers (*see page 270*). For example, one pound of DNA has more storage capacity than all the silicon-based computers that have ever existed, and DNA is plentiful and relatively cheap. Computers harnessing this potential should be able to perform calculations in parallel rather than linearly (as conventional computers operate). This will vastly increase their speed and reduce their size, enabling computers the size of a raindrop to outperform the fastest of today. Similar ideas are being explored using a 'soup' of different chemicals with operations performed by chemical reactions.

Freeway to flyway

Could flying cars, the promise of so many sci-fi predictions, finally become a reality? Current research suggests that they will be on the market within two decades. Prototypes of private vertical takeoff vehicles already exist. The main drawback involves their control technology, but computer modeling, GPS, and 3-D positional software is solving these problems.

Digital warfare

Technological advances in weapon systems are always at the cutting edge of our knowledge due to the massive expenditure on defense research budgets. In this sometimes surreal world reality can be stranger than science fiction. This image is of a pilot's helmet from the new F-35 Joint Strike Fighter, a state-of-the-art development providing the pilot with unprecedented levels of information and control. In addition to the features detailed below, digital cameras mounted on the exterior of the fighter allow the pilot to access views to the side, above, below, and behind the aircraft.

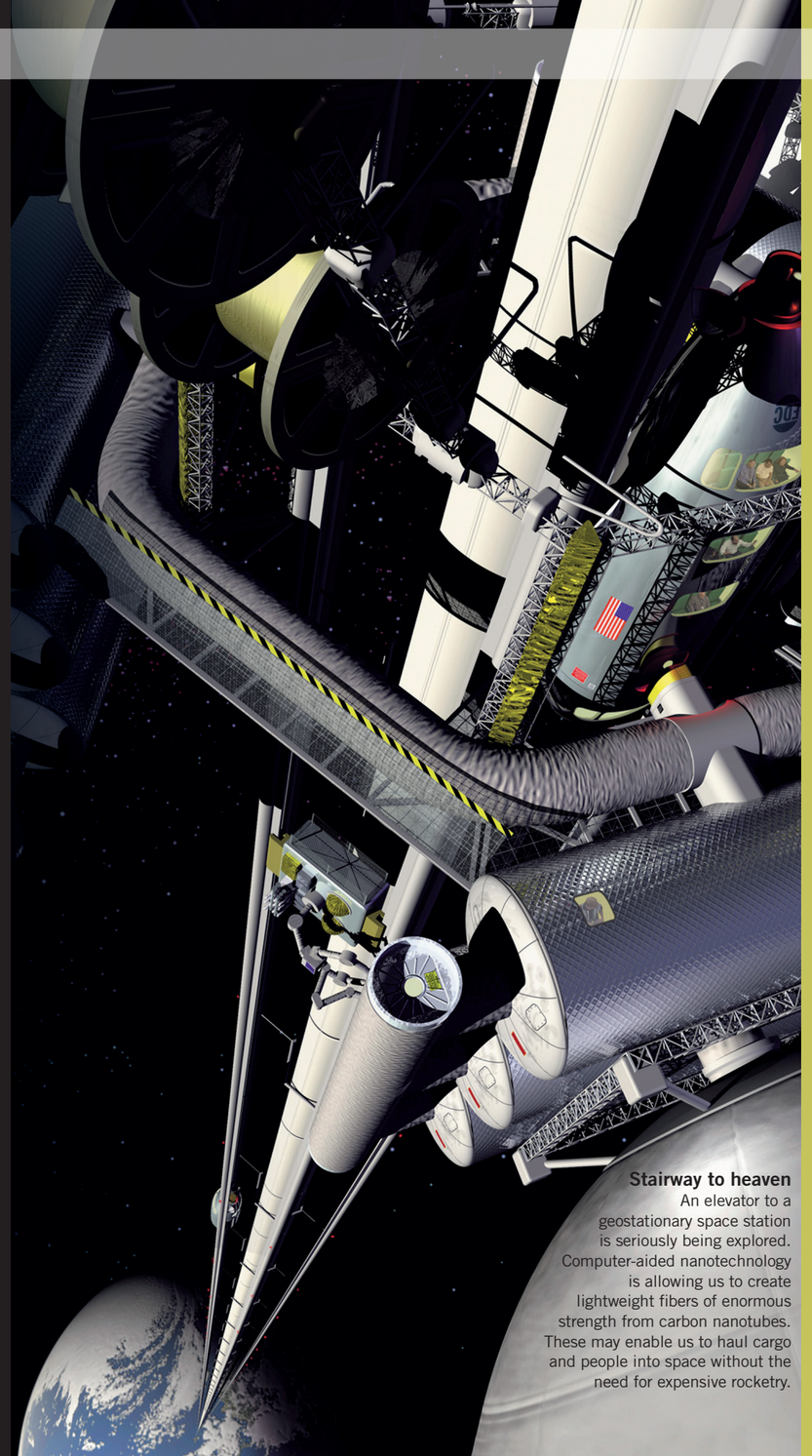
Twin projectors
These beam a range of images onto the interior of the tinted visor.

Vocal commands
Most of the digital functions can be activated by voice.

Data cable
The digital feed supplies data and relays commands.

Oxygen supply
Air is pumped into the pilot's lungs at high pressure.

Earphones
These relay radio messages and synthesized voice information from the aircraft's computerized control systems.



Stairway to heaven
An elevator to a geostationary space station is seriously being explored. Computer-aided nanotechnology is allowing us to create lightweight fibers of enormous strength from carbon nanotubes. These may enable us to haul cargo and people into space without the need for expensive rocketry.

Into the matrix

With processors functioning at the atomic scale, we may soon see a world in which superfast, minute computers are printed onto objects or the skin, communicating through a quantum network. Reductions in scale and cost are already allowing microprocessors to be attached to everyday objects such as RFIDs; with wi-fi technology and sufficient bandwidth they will soon be communicating spontaneously with each other and collecting information via the Internet. Lawn sprinklers will read weather forecasts; children's clothes will reveal their whereabouts via GPS systems; medicine cabinets will automatically identify the drugs they contain and warn of possible adverse interactions; and food packaging will communicate with the oven to tell it how the food it contains is to be cooked.

It is likely that the majority of computing power will be moved out of our homes and offices to vast, remote computer sites. Our terminals will become reduced to a wearable size – wristwatches or perhaps headbands with constant access to the Internet, feeding us information about the world, aware of our location and environment, and able to infer our desires and intentions.

Plugging in

Brain-computer interfaces (BCIs) are becoming increasingly sophisticated, along with our ability to decipher the brain's electrical activity. People can already move cursors and write messages on computer screens by thought alone using sensors mounted on the scalp. Monkeys have been trained to feed themselves using robotic arms linked to brain sensors, and we have seen through cats' eyes by interpreting signals from electrodes placed in their brains (*see page 277*). Given this, we can envisage a world in which humans and machines are married together to enhance our cognitive skills, and keep us healthy, informed, connected, and entertained. Anything and everything could be coupled to the Internet – with dire consequences for our privacy. Will we accept electrodes hardwired into our brains? The only brakes on the process are cultural: do we consider this desirable or an Orwellian nightmare?