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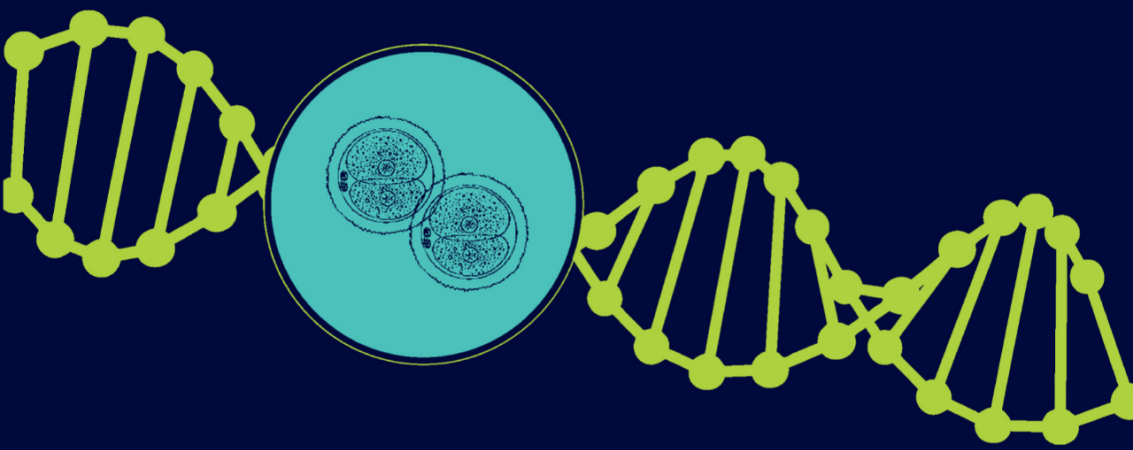

30-SECOND BIOLOGY

THE 50 MOST THOUGHT-PROVOKING THEORIES OF LIFE, EACH EXPLAINED IN HALF A MINUTE

Editors **Nick Battey & Mark Fellowes**

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CONTENTS

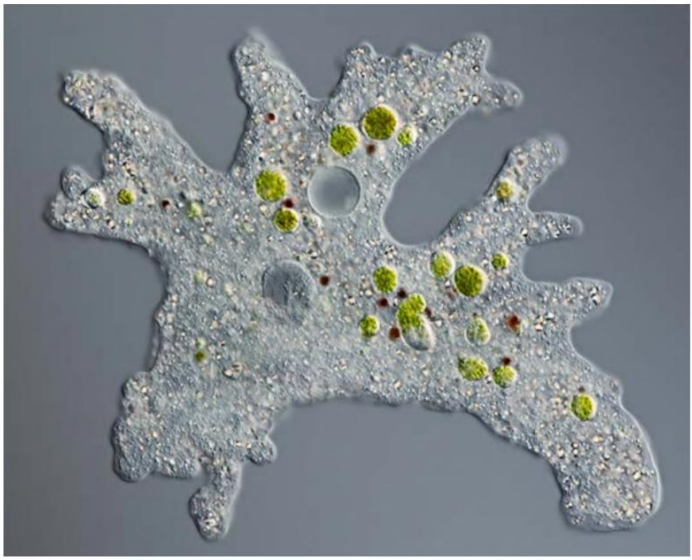
INTRODUCTION

Nick Battey & Mark Fellowes

It's a little over 200 years since the word 'biology' was invented to identify the part of the natural world capable of reproducing and maintaining itself. In the beginning it attracted vitalist thinking (the assumption that life required some mysterious 'force' to sustain it), as people sought to account for the unusual abilities of living organisms. But the development of cell theory, physiology and the theory of evolution in the nineteenth century gradually helped to fill the gaps about how life worked. In the twentieth century genetics, biochemistry, molecular biology and developmental biology established clear mechanistic knowledge of the way life runs itself, showing how the features and processes characteristic of organisms are regulated during the life of the individual and passed on to offspring. At the same time, ecology, evolutionary biology and biogeography became key disciplines for understanding the behaviour and interactions of populations of organisms with each other and their environment. The subdisciplines of zoology, botany, microbiology and virology elucidated the details of how life within the different kingdoms worked, while taxonomists and systematists explored its hierarchies and origins.

Twenty-first century science

The domains of biology continue to expand, making it no exaggeration to claim that it is the science of this century; there is little of global importance that is not touched by it. Biomedicine, including regenerative medicine and medical genetics, is exploiting biological knowledge to give ever-increasing control over life, death, illness and disease. At the same time, the other aspects of biology allow us to engage with the crucial problems that threaten to overwhelm society – climate change, population growth, pollution, food shortages, erosion of natural resources and species invasions. In a sense the integrative, ecological dimensions to biology take on the consequences of advances in human biology. As the dominant discipline of the Anthropocene (the proposed new geological epoch that reflects the current human domination of our planet, see page 150), biology conditions



Amoeba proteus *is a tiny one-celled organism often found in freshwater environments.*

what we can do and shapes how we deal with the results of our actions. Almost everything that matters is affected by biology.

The one notable absence from this brief appraisal is culture. Broadly speaking, culture can be considered to be the consequence of human consciousness, passed on through the generations not by genes but by one form or other of mental transmission. Psychology deals with the human mind, and we have not considered it part of biology in this book because it is a distinct subject with largely separate traditions to biology; and biology itself is anyway big enough as originally defined. But an obvious prediction is that rigorous biological explanations of the way the mind works, and eventually of the way culture works, will be definitive advances when viewed from the perspective of 2050: that the *30-Second Biology* of that date will include the science of the mind as a dominant feature. A different guess might be that biological explanations of the mind and the culture it generates are prosaic: what matters is not what causes culture but what it means to us, a realm in which biological explanations may be of little interest. Not so, though, the central place of biology in the future life of the human species. How we deal with a rapidly growing (and ageing) population, the destruction of habitats,

The impact of climate change and human settlements on the alpine habitat of snow leopards makes them an endangered species.

and how we regulate what we do with our biological power, will be critical issues that it will take all our biological and cultural skills to address.

How this book works

In *30-Second Biology* each topic is clearly and concisely presented on one page in a punchy single paragraph: the **30-second theory**. For an even quicker overview, there is the **3-second dissection** alongside – the key facts encompassed in a single sentence. Then the **3-minute synthesis** fleshes this out, addressing a thought-provokingly quirky or intriguing aspect of the subject. Each chapter also contains the biography of a pioneer or high achiever in the field – people such as Norman Borlaug, the developer of high-yielding, semi-dwarf wheat, who is credited with saving millions from starvation and hailed as the 'father of the green revolution'.

The book begins with **Life**, a scan of the major groups of living organisms. It then discusses **Genes**, the blueprint of life, and, in **Genes to Organisms**, looks at how the information encoded by genes is transformed into the cells and tissues of living organisms. Next **Growth & Reproduction** are considered, focusing on these processes in plants, animals and bacteria. **Energy & Nutrition** looks at how energy is converted into life, and how living processes maintain and are maintained within bodies. Finally, the chapters on **Evolution** and **Ecology** discuss how life arose, how organisms live together and the peculiar strains placed on these relationships by the phenomenal growth of the human species. It is this dominance that threatens to destabilize everything on the planet; the growth of biology is one reason for it, but understanding how life works and how organisms interact seems to us something intrinsically beautiful. Let's see if that category still exists in 2050.

LIFE

LIFE
GLOSSARY

biofilm Self-sufficient community of bacteria in which different species may cooperate, some recycling the wastes of others. Dental plaque is a biofilm.

cell Smallest unit of an organism, typically but not always consisting of a nucleus and cytoplasm encircled by a membrane. Many microscopic organisms – such as bacteria and yeasts – consist of just one cell.

centrioles Organelles (compartments within a cell) found in pairs close to the nucleus in animal cells. Centrioles play a key role in cell division.

chloroplast A plastid (type of organelle) found in the cells of green plants, in which photosynthesis occurs.

choanoflagellates Free-living single-celled microscopic eukaryotes believed to have been the evolutionary ancestors of animals. They are flagellate – they contain whip-like organelles known as *flagella*.

cloning Asexual reproduction of genetically identical copies of an original organism or cell. Cloning occurs naturally: plants' and animals' body cells are ultimately clones of an original fertilized egg. Cells are also cloned in the laboratory: for example, the nucleus can be removed from an egg and replaced with the nucleus of a cell of the type to be cloned.

cyanobacteria Single-celled prokaryotic organisms that derive energy through photosynthesis. Also known as blue-green bacteria, they are the earliest known lifeform on Earth – their fossil record in western Australia dates to 3.5 billion years ago.

cytoplasm The part of a cell that surrounds the nucleus and is enclosed by the cell's outer membrane – the cellular membrane.

DNA Deoxyribonucleic acid, a molecule that carries the coded genetic information that transmits inherited traits. DNA is found in the cells of all prokaryotes and eukaryotes.

Dolly the sheep The first mammal to be cloned from an adult cell. In 1996 a team from the Roslin Institute and biotech firm PPL Therapeutics cloned Dolly, a domestic sheep, from a sheep's mammary gland cell using the nuclear transfer method (adding new genetic material into a cell from which the original genetic material had been taken out). Dolly was genetically identical to the sheep whose genetic material was added to the mammary gland cell. She lived more than six and half years from 5 July 1996 to 14 February 2003.

eukaryote Organism or cell that has a discrete nucleus.

MUSCLES

the 30-second theory

Muscles are about movement: humans walking, fish swimming, birds flying. They also cause movement inside the body, such as the heartbeat, which in humans typically occurs about 60–70 times per minute, supplying oxygenated blood to all organs – including other muscles. For physical movement of the body, muscles are firmly attached to the bones of the skeleton, and hence called 'skeletal' muscles. These are made from bundles of individual muscle cells, each cell containing parallel bundles of protein filaments (myofibrils). Nerve impulses stimulate these cells to contract, exerting kinetic force on the part of the skeleton to which the muscle is attached and creating movement. The other main type of muscle is smooth muscle, which is not connected directly to the skeleton, but is a component of internal organs such as the reproductive system and the intestine. Smooth muscles typically contract in a phased manner, which creates a controlled wave of movement. The muscles that deliver the most force in the body are the uterine muscles, used when mammals give birth to live young. Muscle is also a major source of dietary protein for carnivorous animals, and to a large extent for omnivores (like us); eating roasted skeletal muscle is not something we usually think about when sitting down for dinner.

3-SECOND DISSECTION
Muscles rapidly change chemical energy in an organism into some form of movement.

3-MINUTE SYNTHESIS
There are around 650 skeletal muscles in the human body. The myofibril filaments within muscle cells are mainly made of the proteins actin and myosin. In addition to enabling animals to move about in their environment, muscular movements are needed for sensory evaluation – for example moving and focusing the eye. Muscles in the thorax and larynx facilitate the generation of sound and the use of language; facial muscles enable emotional and non-verbal communication.

RELATED TOPICS
See also
REPRODUCTION: ANIMALS
page 78
METABOLISM
page 100
EXCRETION
page 104

3-SECOND BIOGRAPHY
H.E. HUXLEY & A.F. HUXLEY
1924–2013 & 1917–2012
Brilliant English physiologists who made breakthrough advances in muscle and nerve biology

30-SECOND TEXT
Tim Richardson

We rely on muscles not only to move around but to see, to speak, to smile or frown, to swallow and digest food – and to pump blood around the body.

CIRCULATORY SYSTEM

the 30-second theory

Animal cells require a constant supply of nutrients and oxygen from the environment, and they produce waste products that are released back into the environment. Complex species with many cell layers have developed supply mechanisms that deliver nutrients to cells and remove waste, known as circulatory systems. These have three basic components: fluid (in the case of blood containing many cells), a pump (the heart) and a complex network of tubes or vessels. In insects, spiders and crustaceans the circulation is open and the fluid transported (haemolymph) bathes the tissues and their component cells, and is sucked back into the vessels during heart relaxation. In all vertebrates blood is confined to the vessels and is under pressure that surges as the heart beats. Mammals and birds possess a double circulation system: between the heart and the lungs; and between the heart and the rest of the body. This enables blood to travel to the lungs, release waste carbon dioxide and pick up oxygen, before returning to the heart, which then pumps the fuel-filled blood to the rest of the body through a network of arteries. Arteries divide into smaller and smaller vessels (capillaries) that permeate into all tissues, ensuring that every cell is close to the supply network. Blood returns to the heart through veins, and the cycle begins again.

3-SECOND DISSECTION
Circulatory systems across the animal kingdom supply cells with nutrients and oxygen and carry away the waste products of cell function.

3-MINUTE SYNTHESIS
Natural selection has enabled the development of mechanisms that protect the circulatory sytem, preventing the loss of blood. Damaged or broken blood vessels trigger the blood to clot, preventing further leakage, while blood flow in healthy vessels prevents blood clotting. Diseases of blood vessels, often caused by the accumulation of fatty deposits, can result in clotting inside vessels that in humans leads to heart attacks and strokes.

RELATED TOPICS
See also
RESPIRATION
PAGE 94

METABOLISM
page 100

NUTRITION
page 102

EXCRETION
page 104

3-SECOND BIOGRAPHY
WILLIAM HARVEY
1578–1657
English physician who discovered the organization of the human circulatory system in 1628

30-SECOND TEXT
Jonathan Gibbins

In our double circulation blood pumped from the heart to the lungs returns enriched with oxygen, then is distributed via the arteries before coming back via the veins.

INDEX