

## Human Evolution and Development



# Human Evolution and Development

*Textbook for Life Sciences*

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# Table of Contents

Preface	7
1. The story of our ancestors	11
The revolutionary innovation: walking upright	11
How old is that fossil?	14
The hominin tree	17
The earliest hominins	20
The heyday of the ape-men	22
The first <i>Homo</i>	25
Towards modern times	32
2. From ovum to human	37
Heterochrony and Haeckel's law	37
Cleavages and germ layers	41
Axes to provide direction	48
Model animals in developmental biology	52
The molecular toolkit for development	59
New axes for limbs	64
3. Our tinkered body	69
Tinkers, watchmakers and a Boeing 747	69
The naked human	73
Adaptations to bipedalism in the locomotor apparatus	77
Gill slits, larynx and middle ear	84
The intestines and the lung	87
Heart and urogenital system	91
Evolution of the brain	99
4. There must be differences	109
Giant leaps, neutral fluctuations or gradual adaptation?	109
The emergence of variation	114
Equilibrium between allele and genotype frequencies	124
Neutral evolution	135
Geographical distance causes genetic differences	140
On top of genetics	142

5. The past in the present	151
Phylogenetic reconstruction	151
The molecular clock	161
Out of Africa or multiregional evolution?	164
Migrations in all directions	170
Hybridisations between ancient humans	176
6. The cultural human	183
Prehistoric tools and cave drawings	183
The Neolithic transition	192
Language: early or late?	198
Living in groups: altruistic behaviour	201
Cultural evolution	208
7. Do humans still evolve?	215
Quantitative characters and heritability	215
Ecogeographic variation in human body form	221
Evolution of biomedical traits	224
Evolution of the life cycle	229
Partner choice and sexual selection	230
Evolutionary medicine	235
Epilogue	241
Further reading	245
Primary literature	249
Credits	275
Index	281

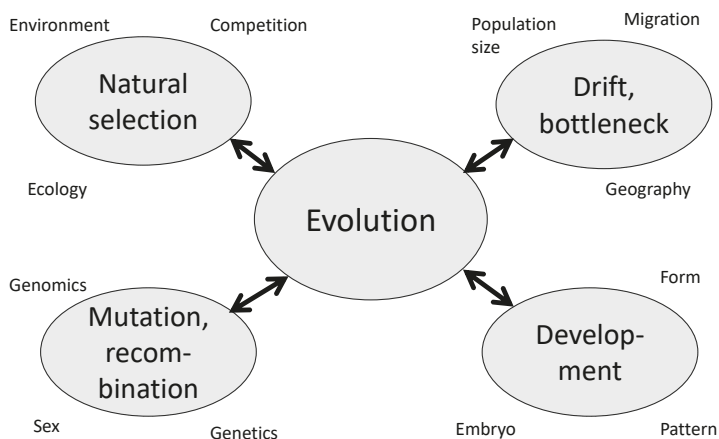
## Preface

No scientist will doubt nowadays that humans are a biological species, subject to the same evolutionary mechanisms as all other biological species, but how that evolutionary process took place exactly and which selective forces made us into what we are now, is still largely uncertain. Over the last ten years, however, research on human evolution has rapidly gained momentum. This was caused in the first place by the discoveries of a large number of new fossils. In 1964, a 'golden period' started for human palaeontology, and a clear understanding of human ancestry began to take shape. Since 2002, a large number of spectacular discoveries added to our knowledge, thoroughly adjusting our idea about the diversity of our ancestors. Many of those discoveries were and continue to be published in newspapers or otherwise reach the general public. Over the last years, however, the number of species has increased such that for laymen it has become almost impossible to maintain a proper overview. One of the objectives of this book is to present the abundance of extinct ape-men and humans in a coherent story.

Secondly, modern biotechnology has allowed us to map the DNA of humans in such a detailed way that important conclusions can be reached about our evolutionary history. The genetic variation among humans, in conjunction with the places where they live, the languages they speak and the cultures they share, are an invaluable source of knowledge for evolutionary reconstruction: a large part of our evolutionary history is stored in the current DNA. Due to the enormous development of DNA research and the possibility to sequence and compare entire genomes of hundreds of people simultaneously, we are now able to tell much more about human evolution than a number of years ago.

Thirdly, it has also proven to be possible to isolate DNA from fossil material, provided that it is not too old (currently to approximately 400,000 years). In 2010, sequencing of ancient DNA led to the astonishing conclusion that humans must have crossbred with Neanderthals. For us, teachers of evolutionary biology, this was one of the most shocking events, because for many years we had taught our students that humans and Neanderthals were two biologically separated species.

Lastly, we emphasise that over the last years evolutionary biology has become integrated with developmental biology. A new area of expertise is developing, referred to as 'evo-devo'. Every animal develops from a fertilised ovum, via the embryonic and foetal stages into a mature and reproducing individual. The genetic machinery managing this development is beginning



to be understood for an increasing number of model species. Evolution is a process of change in the way genes regulate that development and thus alter the external appearance of a species.

Evolution is, in fact, the result of four different drivers (see figure). The basis for evolution lies in genetics. Changes in the hereditary material (mutations) take place continuously, recombine between individuals as a consequence of sexual reproduction, and are passed on to offspring. Mutation and recombination generate the variation that becomes available for selection. Natural selection subsequently ensures that mutations that provide beneficial properties to the individual are maintained and spread within the population at the expense of less beneficial variants. In a small population, mutations can also settle due to genetic drift and bottleneck effects, which is the subject matter of neutral evolution theory. Finally, embryonic development has a strongly integrating and canalising effect on the possibilities for evolution, as any mutation should fit into the genetic machinery directing an organism's body plan before it can become manifest as an external feature available for selection.

Our book aims for an integrative approach of evolutionary biology, considering mutation, recombination, natural selection, neutral evolution and developmental processes in mutual interdependence. Our focus on developmental biology distinguishes this book from other books on human evolution. The appearance of a new and unique developmental plan, a human body, which differentiates in many respects from the great apes, yet is so similar, demands an explanation in terms of evo-devo. Our body turns out to have been tinkered in a wonderful way, with all kinds of inconveniences and relicts, which are still evident and can only be explained from our evolutionary history.



This book is the result of years of teaching evolution to students of biology, biomedical science and health sciences at the Vrije Universiteit Amsterdam. As part of the course, the students were to apply their obtained knowledge by writing an essay, under the theme 'Do humans still evolve?' This assignment time and again resulted in numerous unexpected and original ideas. This book is our own answer to that question.