Could we communicate with exobeings?

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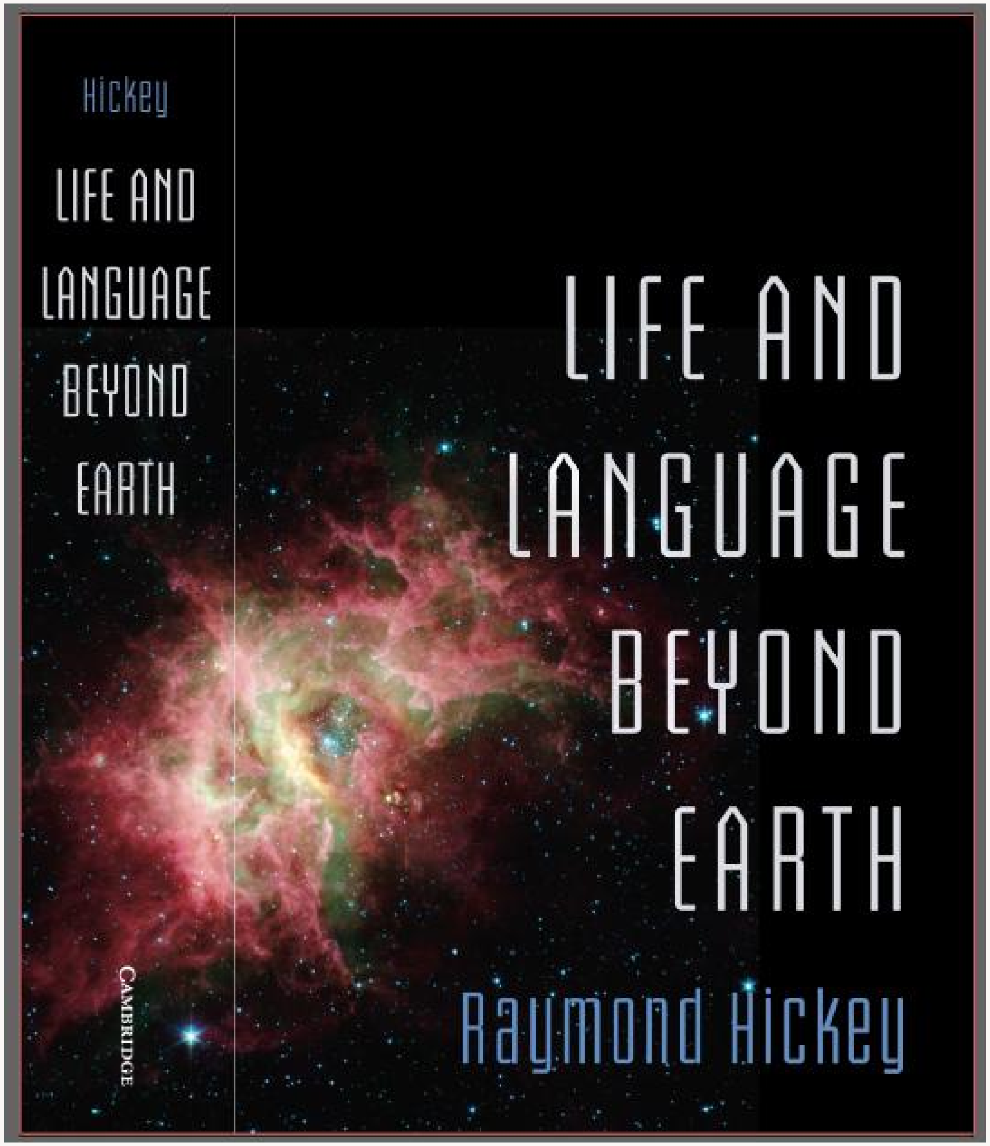
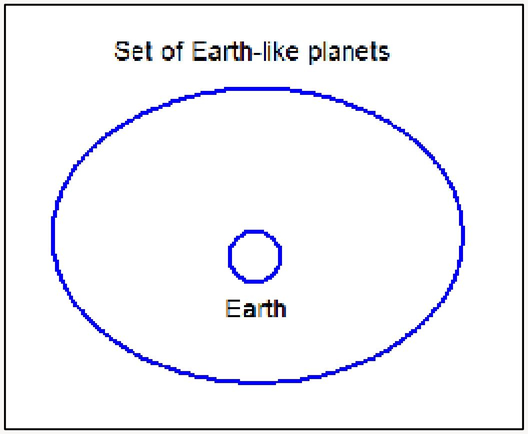


Cambridge University Press, 2023, 655 pages.

Exobeings: Life-forms beyond Earth comparable to ourselves

How much do we actually know about possible exobeings? In fact, nothing. So everything we say on the subject is just conjecture. True. We are dealing with a potential set of planets with intelligent beings, but in reality for us now, this is just a set with just one member, our Earth.

The essential problem is that we have no yardstick for comparison. For instance, take the fact that for almost two billion years in Earth's early history life forms were prokaryotic (simple celled) and only afterwards became eukaryotic (with complex cells). Is this long period of time typical for planetary life? We just do not know.



However, we can look at how life and language arose on Earth and assess the likelihood of the conditions we have had here being replicated elsewhere.

But to begin with, we should consider our position in the universe and consider what our planet has in common with others outside our Solar System.

Astronomy / astrophysics

Bear in mind:

The laws of physics apply across the (observable) universe. From what we know of exoplanets, e.g. by examining their spectral absorption lines, they would have similar elements and compounds as we have in our solar system, so plenty of hydrogen, along with oxygen, nitrogen, carbon, all from stellar nucleosynthesis. Heavier elements from supernovae may well have been present in the proto-planetary disks out of which the exoplanets we observe formed. Liquid water would be available on many planets in the habitable zone of their parent star.

So how rare might Earth-like planets be? There are two basic views:

The Copernican Principle:
Earth is not a special planet, similar planets will be abundant elsewhere.

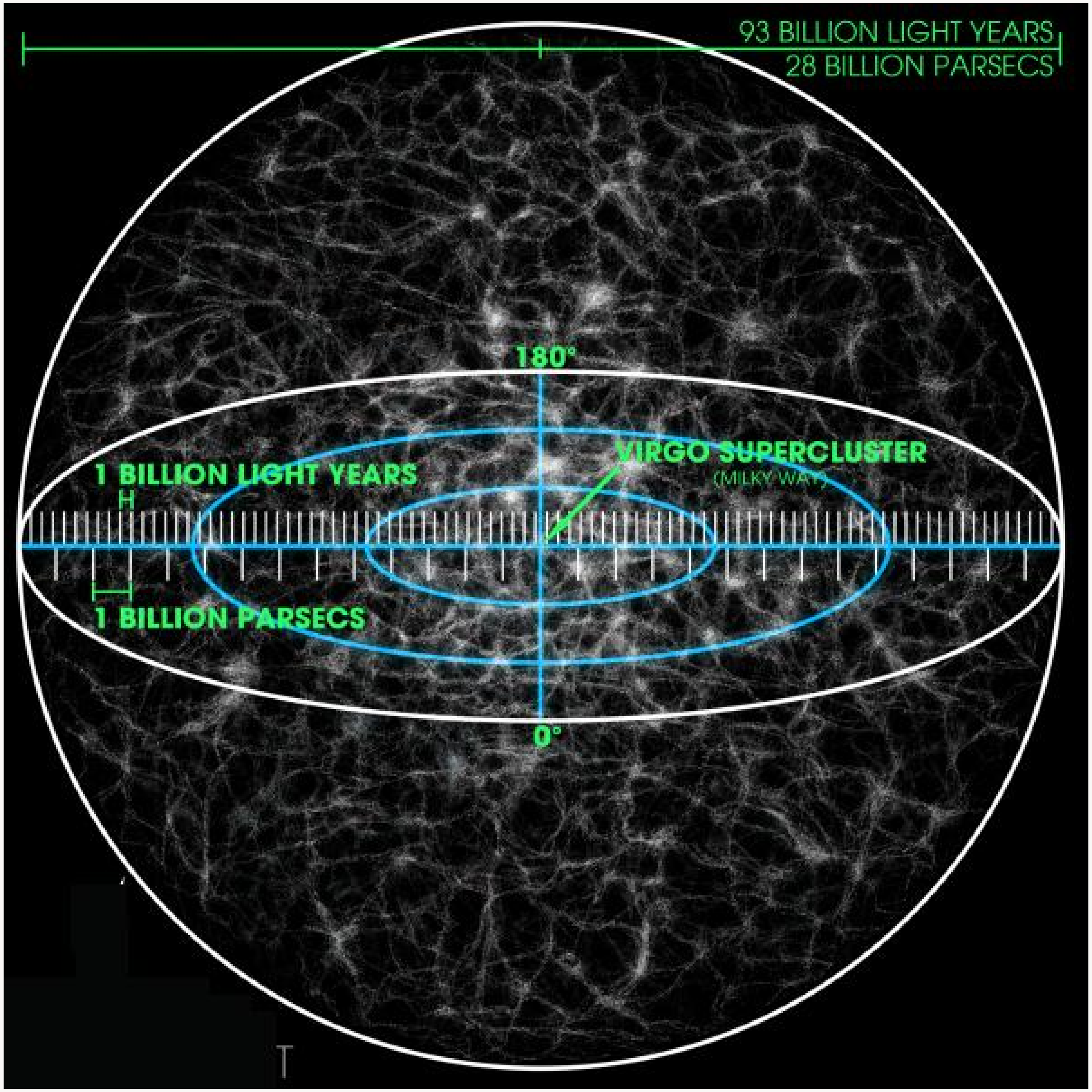
The Rare Earth Hypothesis:
Our Earth is probably unique with its environment which gave rise to intelligent life.

The Observable Universe

Deconstructing the question (1):

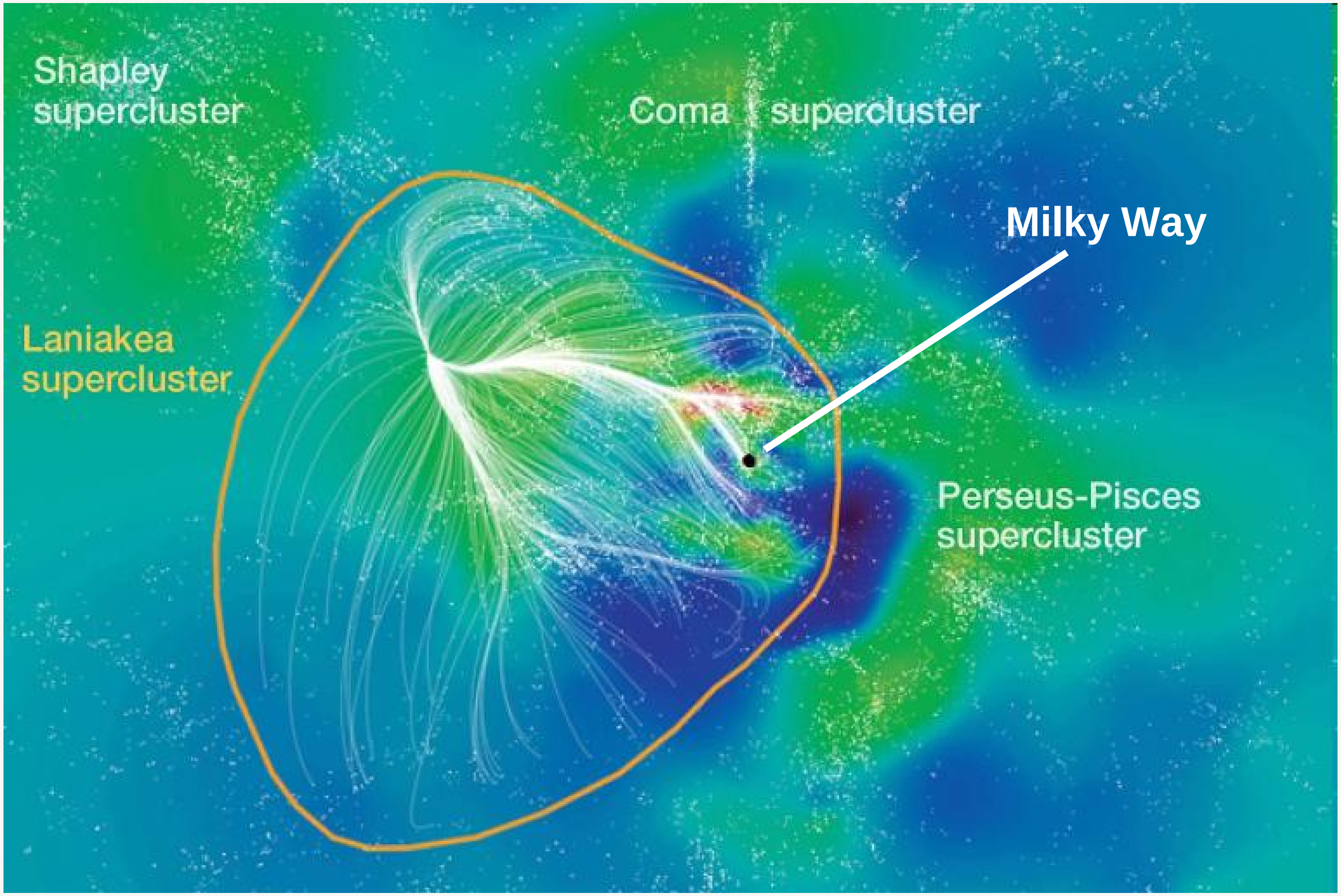
Are we alone the universe?

So, what does one mean by the *universe*?



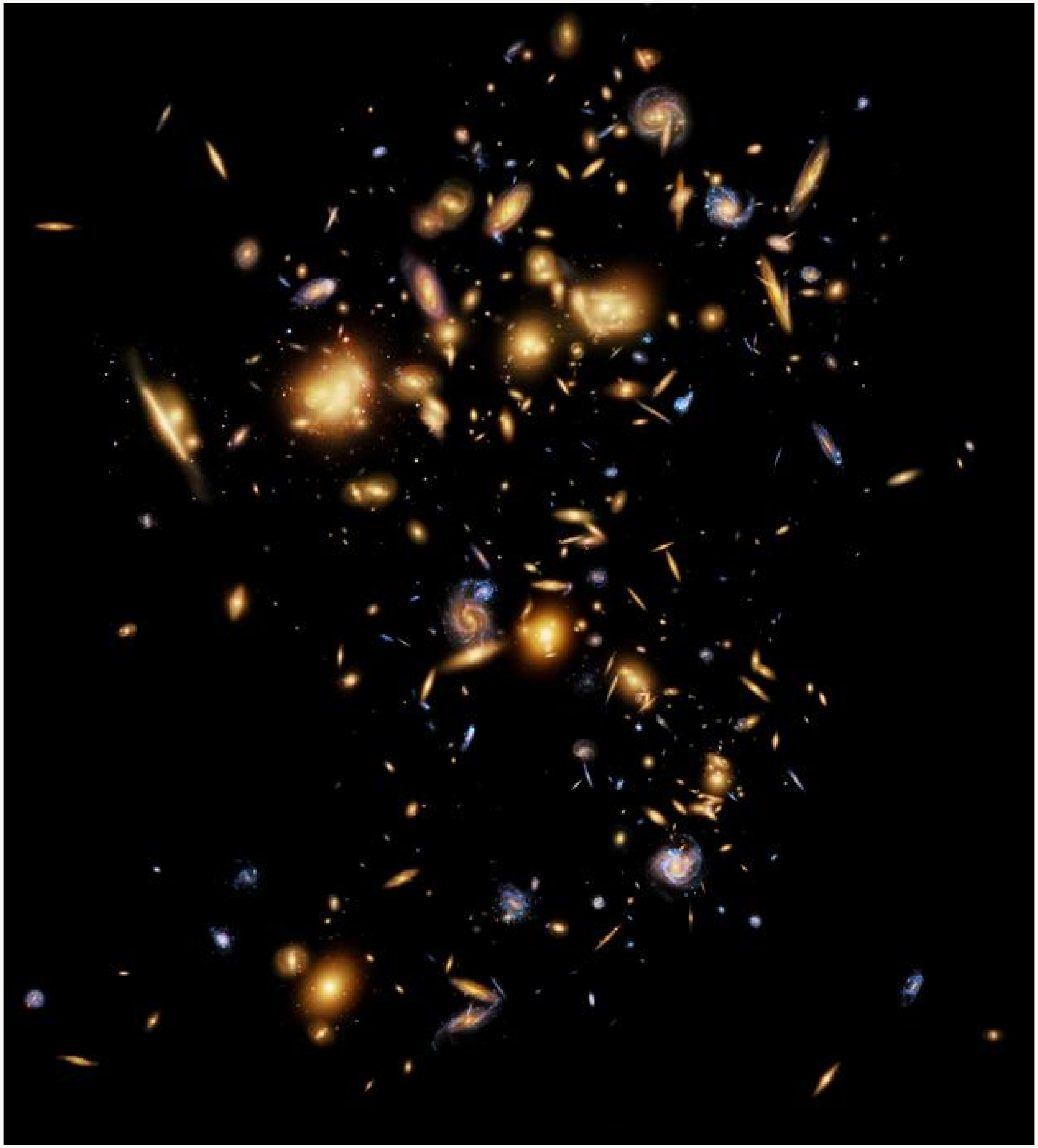
Laniakea supercluster (containing the Virgo Supercluster and smaller groups)

This supercluster is approx. 500 million light years across
and contains about 100,000 galaxies



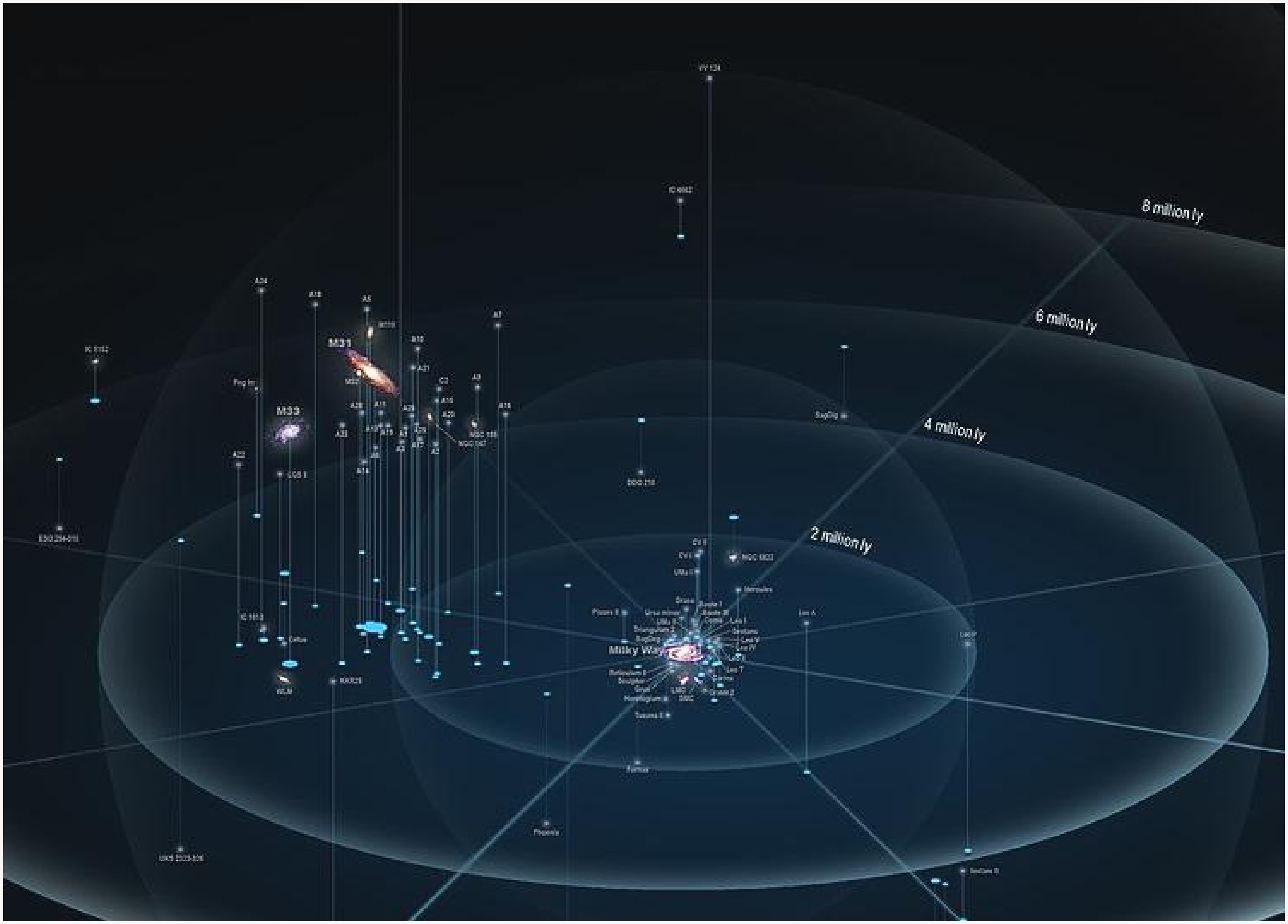
Credit: NASA/ESA/Hubble

The Virgo Cluster, containing up to 2,000 galaxies (in the Virgo or Local Supercluster)



Credit: Pablo Carlos Budassi

The Milky Way and Andromeda (part of the Local Group of galaxies)



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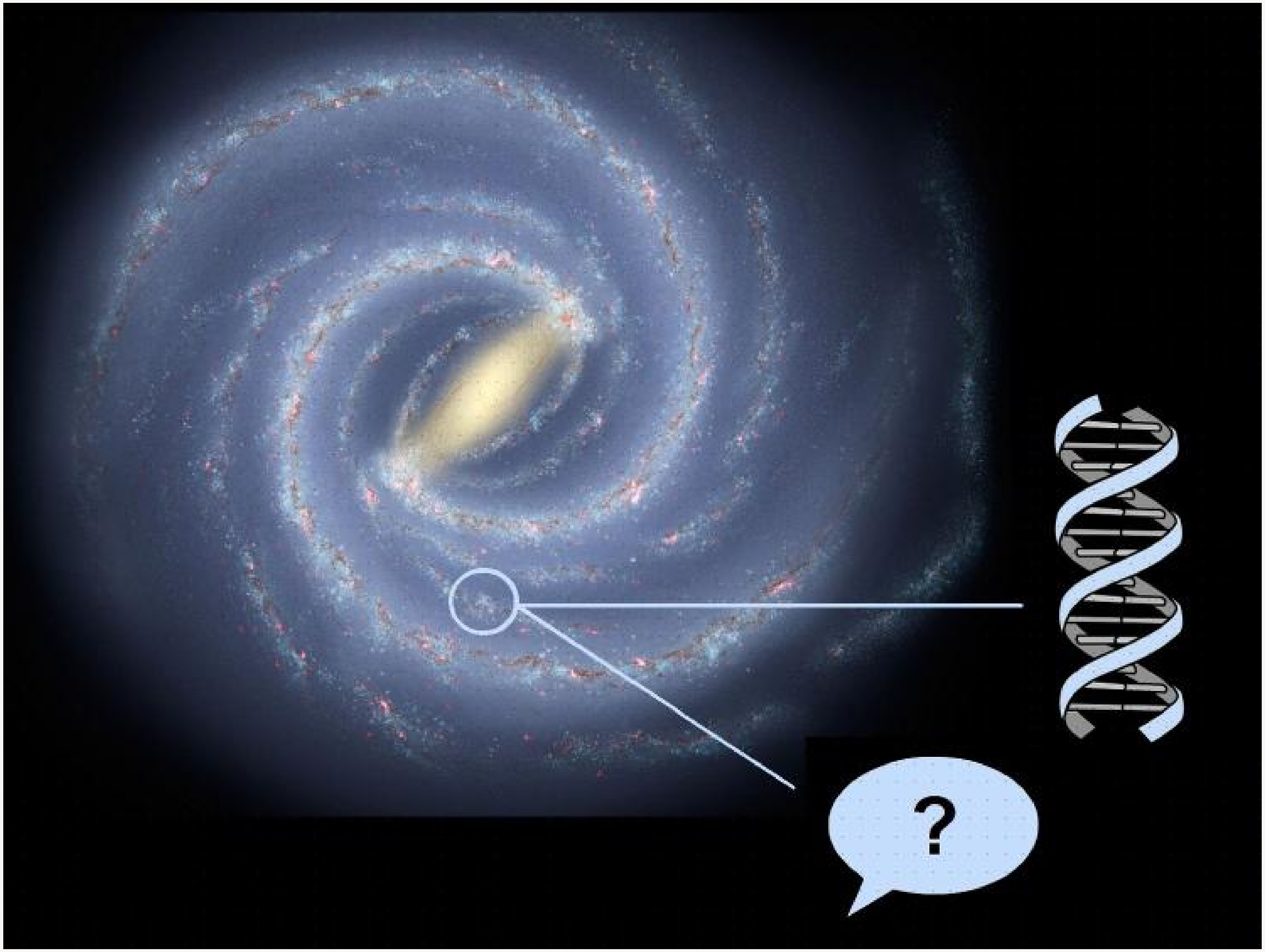
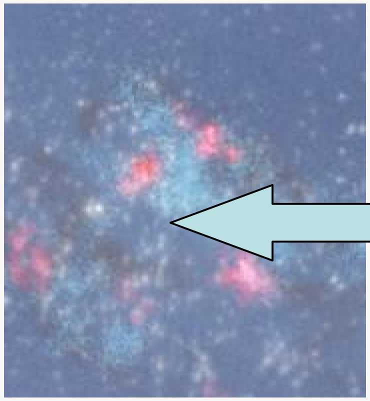
Where we are in the Milky Way

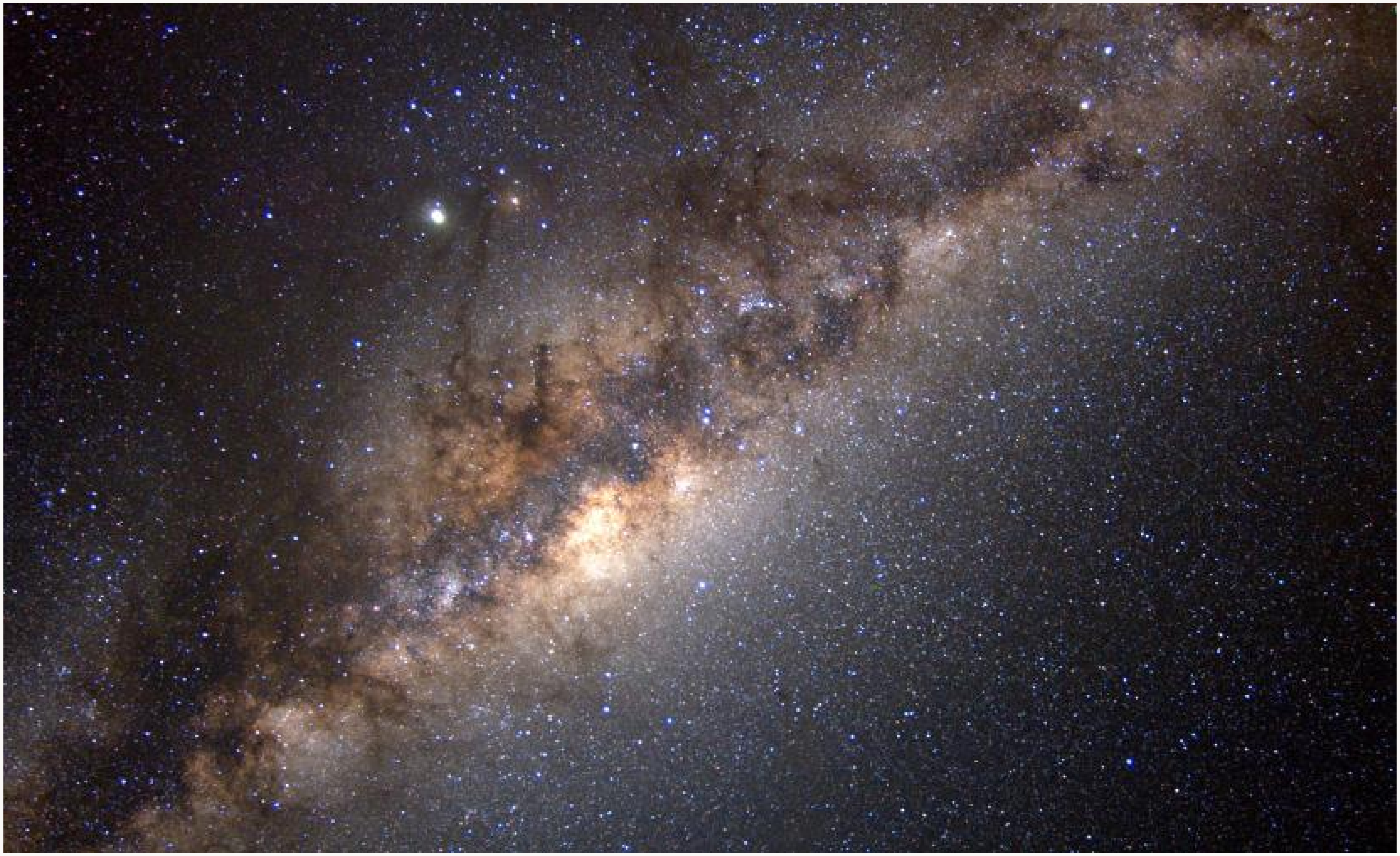


This magnified inset on the previous slide is already about five thousand light-years across



Our Solar system is in here somewhere

We see the Milky Way as a disc-like structure on its side. Any exoplanet with exobeings on the other side of the disc would be permanently inaccessible to us (we are *c* 26,000 light-years from the centre).



Deconstructing the question (2):

Are we alone the universe?

The question should be “Are we alone *now*?”

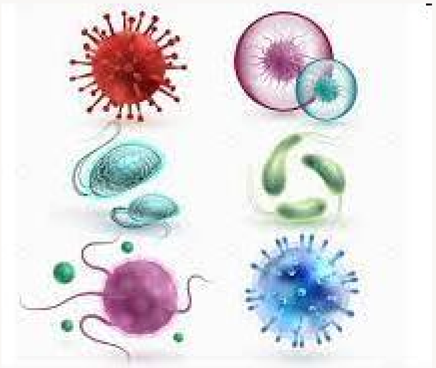
The Earth is about 4.55 billion years old. We have been emitting radio signals from Earth for about the last 100 years. This means that the period of time, when any technological civilisation might be able to pick up a signal from us, is about 0.0000022% the age of the Earth.

To establish contact with an exoplanet with a technological civilisation, it would have to be at a stage in that planet’s lifetime when the technology for interplanetary communication had already been developed. If our Earth is anything to go by, this would be a mere fraction of 1% of the age of such an exoplanet.

Nonetheless, that fraction could be considerably larger than here on Earth: an exoplanet could be 10,000 or 10,000,000 years into its digital age which would probably mean that it would be much more advanced than we are in this respect.

Likelihood of life beyond Earth, in decreasing order

	Category	*Occurrence*	*Some preconditions*
1)	microbial life	common	cell development, maintenance and reduplication
2)	animal life	fairly common	complex cell forms
3)	human-like exobeings, i.e. 'intelligent life'	extremely rare	a 'runaway' brain and manual dexterity

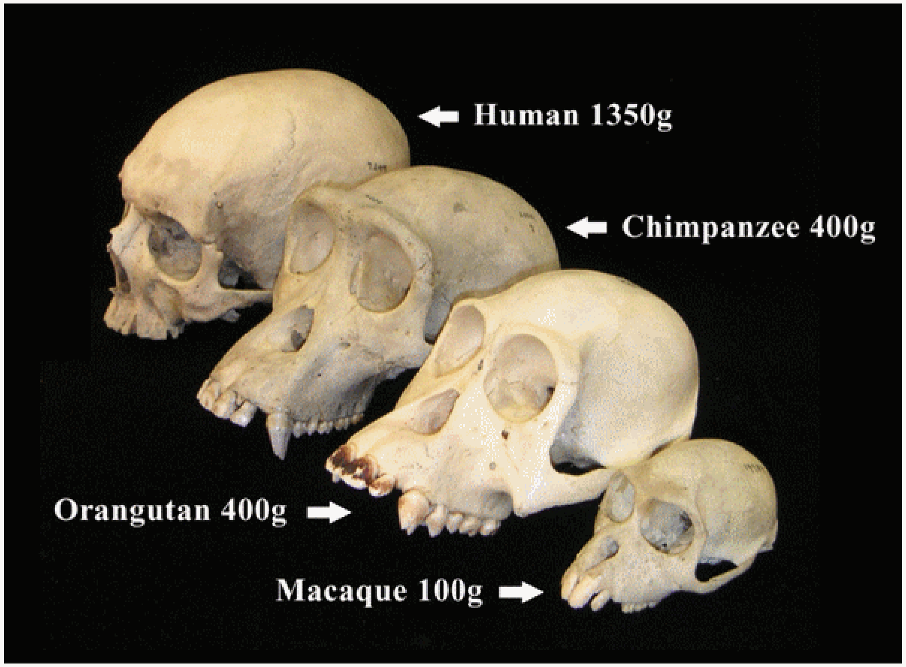


What does one understand by ‘intelligent life’

By ‘intelligent life’ I mean sentient beings who are self-aware, free to move around their environment, capable of reflecting on their surroundings and making voluntary decisions about the actions they take.

On Earth, a high degree of self-awareness, a conception of past and future and in general the ability to think abstractly are regarded as exclusive capacities of humans.

By comparing different animals we conclude that there is an approximate correlation between brain size (relative to body size), especially that of the cortex, and cognitive capacity.



Minimal requirements for exobeings on an exoplanet

1) A rocky planet with liquid water orbiting a star's habitable zone in a calm and stable stellar environment for several billion years. The star should not emit large flares and the planet should have a magnetic field and suitable atmosphere to shield it from cosmic rays.
2) Manual dexterity and cognitive powers to build and maintain sophisticated technical artefacts.
3) The transmission of specialised knowledge across the generations via language.
4) Large-scale societies with a division of labour across a range of activities.
5) The attainment of digital technology capable of communication beyond the exoplanet.

Stability and dynamism of a planet

The long path of evolution

Any planet would need stable environmental conditions over at least several hundred million years to allow for Darwinian evolution to take its course and lead to advanced forms of life, starting with simple cells.

The role of serendipity

Around 66 mya, after the dinosaurs had been reigning for over 150 m years, Earth was hit by an asteroid (probably about 20 km in diameter) which struck just over the coast of the Yucatán peninsula in Mexico. This sealed the fate of the dinosaurs and allowed mammals to flourish when life recovered from this event.

The Tunguska Event in Siberia refers to a meteor which struck on 30 July 1908 completely destroying an area over 2,000 square kilometres, largely of uninhabited forest.

Stage of development

Being out of sync

It is most unlikely that an exoplanet with advanced life-forms would be at just the same stage of its technological development.

However, no matter how far into a possible digital era such as exoplanet might be, its life-forms would still bear the hallmarks of their biological evolution.

Searching for Life beyond Earth

Technosignatures vs. biosignatures

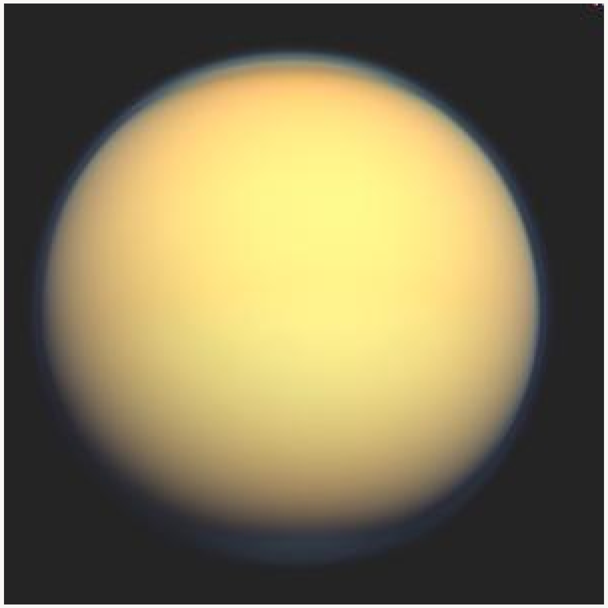
A technosignature is an artificial signal, emanating from beyond our Solar System, consisting of deliberate modulation (of amplitude or frequency) of waves from some part of the electromagnetic spectrum (radio signals or possibly laser beams).

Searches for technosignatures are a type of top-down approach: they will not detect exolife-forms incapable of interstellar communication, no matter how developed these might be.

A biosignature is some piece of evidence pointing to life-forms on an exoplanet or exomoon. Data gathered so far, e.g. spectral lines of light passing through an atmosphere, can point to water, oxygen or methane, which are suggestive of life, but are not unequivocal signs. However, there are plenty of biosignatures, their relative strength is a matter of debate.

Concerns of astrobiology

Astrobiologists are interested in all potential forms of life and indications of these are referred to globally as 'biosignatures'. For example, astrobiologists might wish to see if there is microbial life in the methane lakes on the Saturnian moon Titan. While this is interesting in itself, it is not of relevance to the present discussion, as it would be impossible for a technologically advanced civilisation to arise in an environment at about -180C.



Focusing on technosignatures

Possible conclusions to be drawn about exobeings on discovering an artificial signal from a different solar system.

They would have to be able to construct things and so have high cognitive abilities and dexterous limbs functionally comparable to our hands.

They would have to produce metals and alloys out of which to make their artefacts.

They would have to know electricity and be able to generate it at will as a source of energy for their technical artefacts.

They would need to understand the science of wave transmission in order to undertake interstellar communication.

They would need language to interact with each other when constructing and operating their complex instruments.

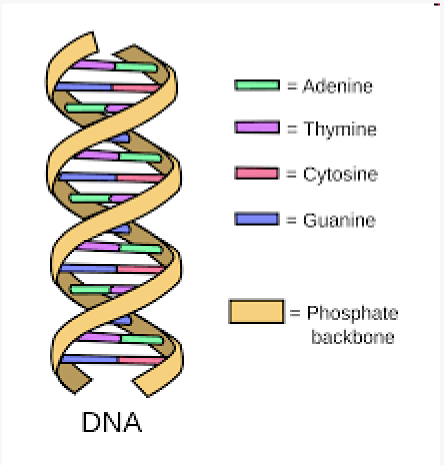
The need for language

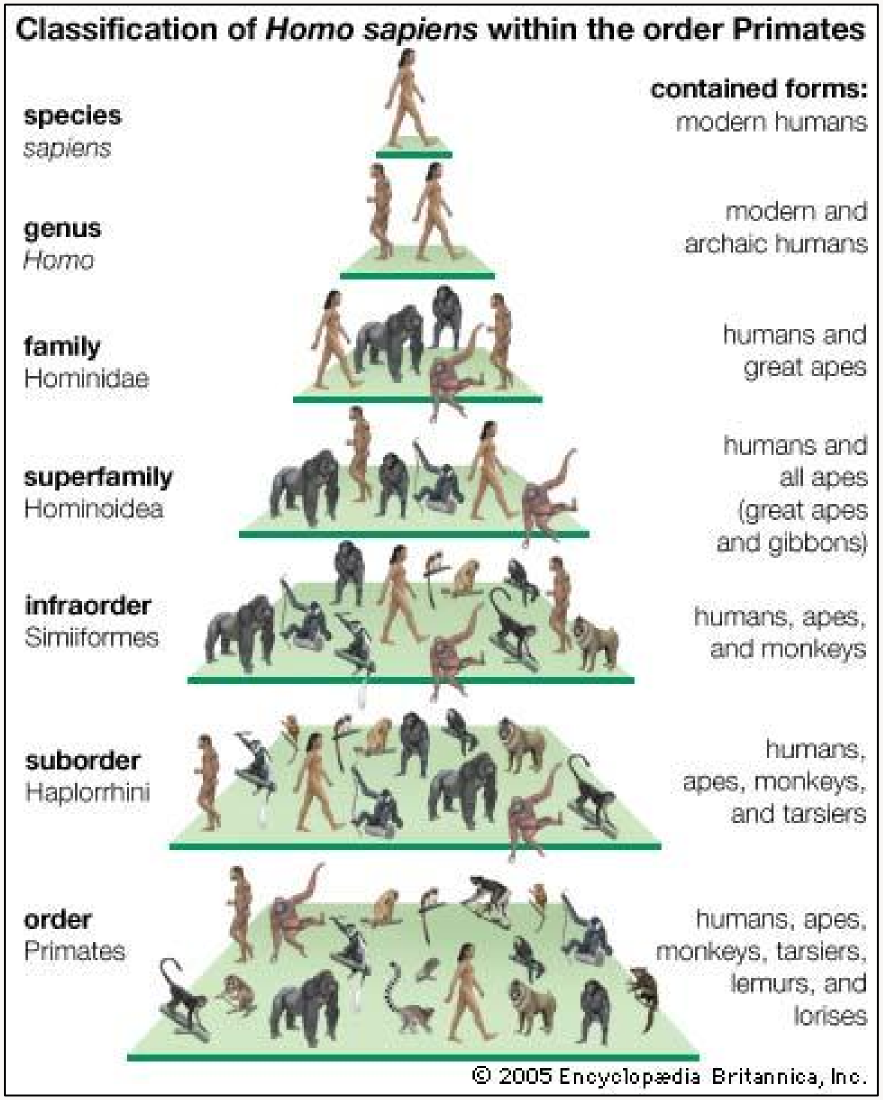
This language would also need some means of storing information in a more or less permanent form to allow for the transmission of complex information across the generations. Whether this would involve artefacts like books (in the history of an exoplanet), and/or digitised representations of language, is an open question.

Evolutionary biology

Any form of life on an exoplanet can only have arisen through Darwinian evolution in which fitness in the environment and natural selection would be the dominant forces driving species development (along with genetic drift and gene flow).

Exobeings would have arisen from less advanced forms of life with which they would most likely co-exist at any one time.





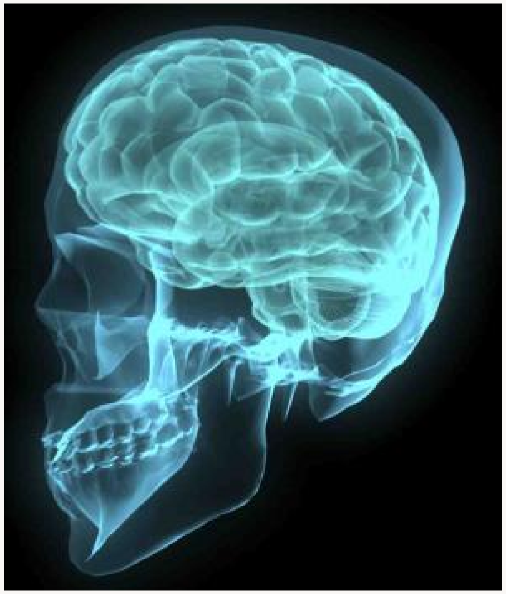
Paleoanthropology

Exobeings would have an evolutionary history of their own, a "paleoanthropology" which would trace their rise from earlier forms of life on their planet. Whether there would be several gradations of exobeings or a large cognitive gap between them and their nearest relatives on their "tree of life" is something we can only surmise but not (yet) determine.

The runaway brain

Humans are notable for having brains far beyond any capacity needed to survive in their original habitats in Africa. There are many contested theories about this, which have to do with factors like fluctuating environmental conditions, social organisation, diet, development of fire and cooking.

Other considerations have to do with manner of breeding: mammals are the most intelligent creatures (just think of sea mammals) so the intimate relationship of mother to child may well have furthered cognition.



Exobeings would also have had to transition to a large-brained species in the course of their evolution, so the questions posed for humans on Earth would apply to them on their planet as well.

Cognitive capacity and manual dexterity

An essential aspect of our evolution is the relationship between cognition and manual dexterity.

We have nails, not claws. In addition to our power grip (using our fists), we have developed a precision grip with the tip of the index finger held against the inside tip of the thumb. Furthermore, we can move our fingers individually. This has allowed us to develop and construct increasingly advanced technology.

Exobeings would have to have similar dexterity of at least two of their extremities, otherwise they could not build anything.

Anthropocentricity

Does my view of exobeings so far sound too anthropocentric, too much like us human beings?

If it does, then there are good reasons for this.

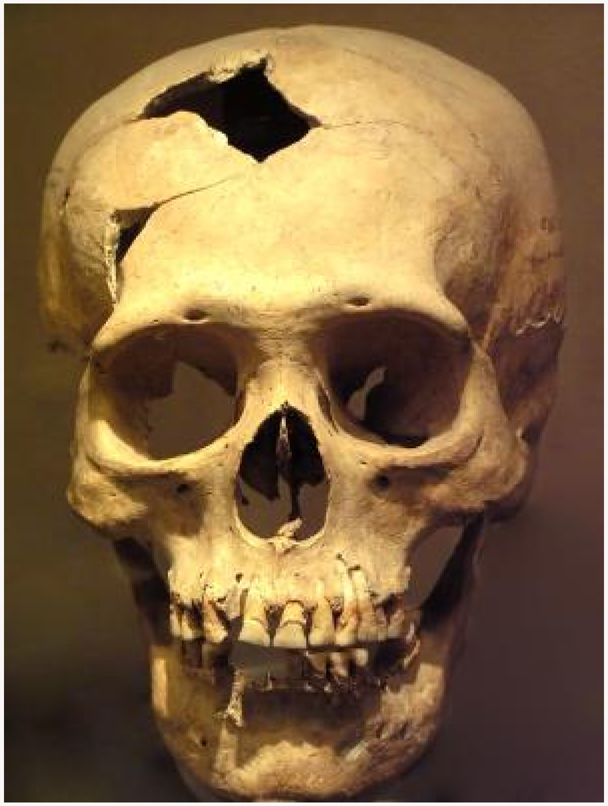
If exobeings were to build a technologically advanced civilisation then they would need advanced cognition and an effective means of communication. On Earth we have big brains and language to do this. On an exoplanet there would have to be equivalents, in principle. In terms of their phenotype, i.e. in terms of appearance, exobeings might look very different from us, indeed they most likely would.

Anthropocentricity

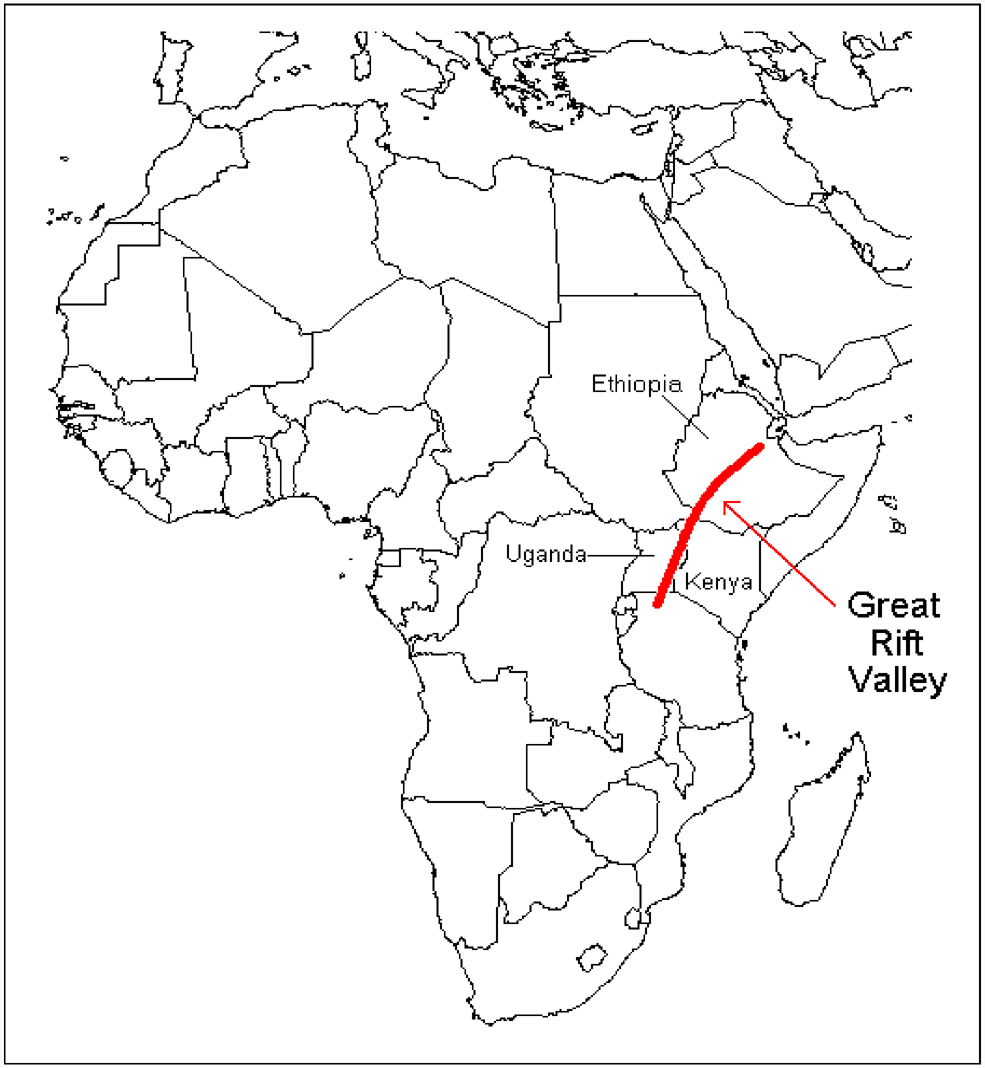
Consider sight for a moment. We know how eyes evolved from light-sensitive cells initially. This also happened independently on a number of occasions, i.e. in evolutionary terms eyes are analogous, not homologous structures.

The majority of animals, which are active during the day, use the sight of their eyes to move around their surroundings, find things to eat, etc. The animals which use echolocation are either (i) nocturnal, like bats, or (ii) sea mammals where echolocation allows for communication over greater distances in water where sight is far more limited than in sunlit air. Of course if exobeings lived on a planet orbiting a red dwarf star then their eyes would be more sensitive to infrared light and would be larger and could be greater in number than two, etc. to compensate for the reduced luminosity of the star.

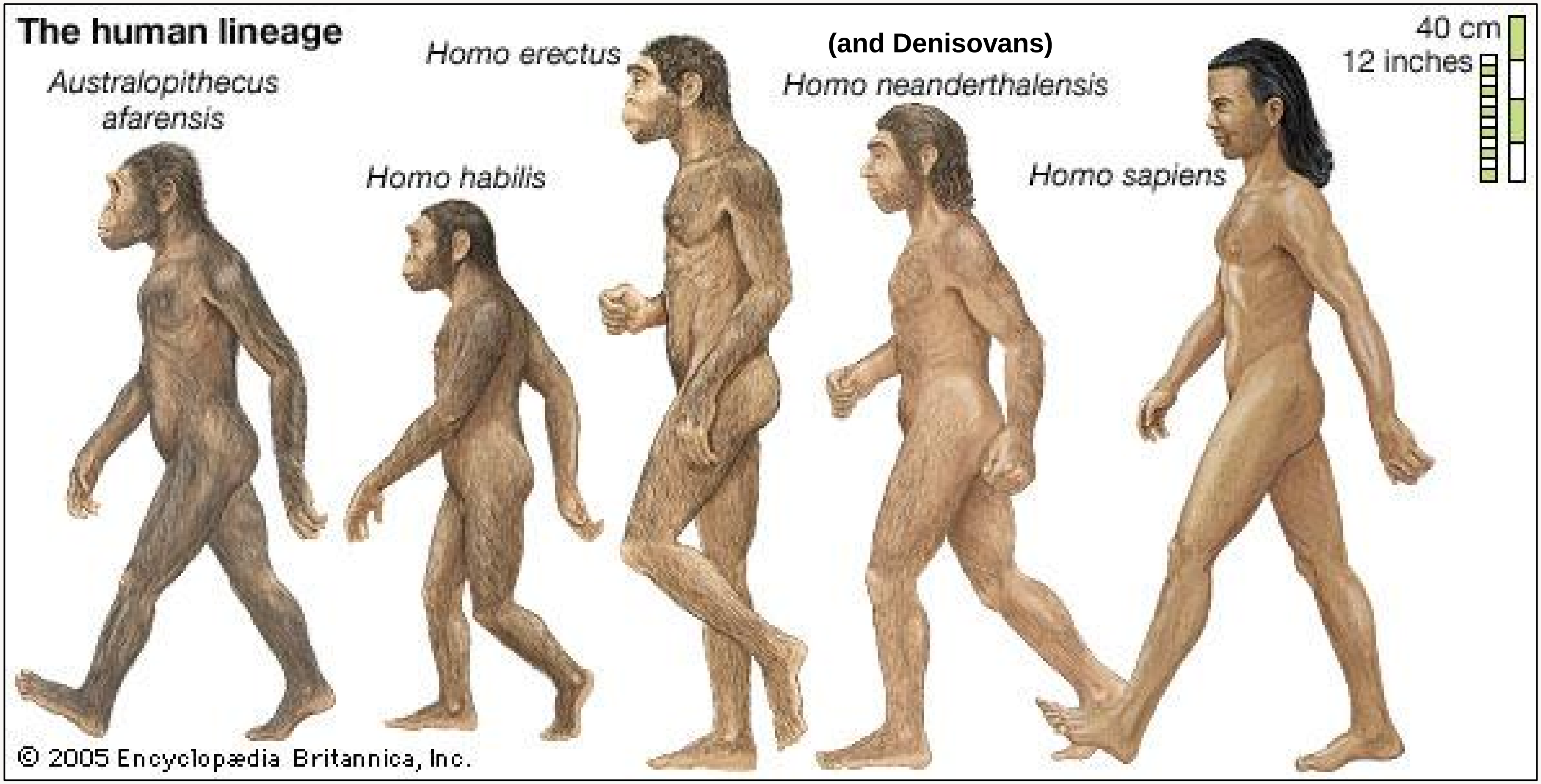
Geographical source area of *Homo sapiens*



Probable area where
Homo sapiens first arose.

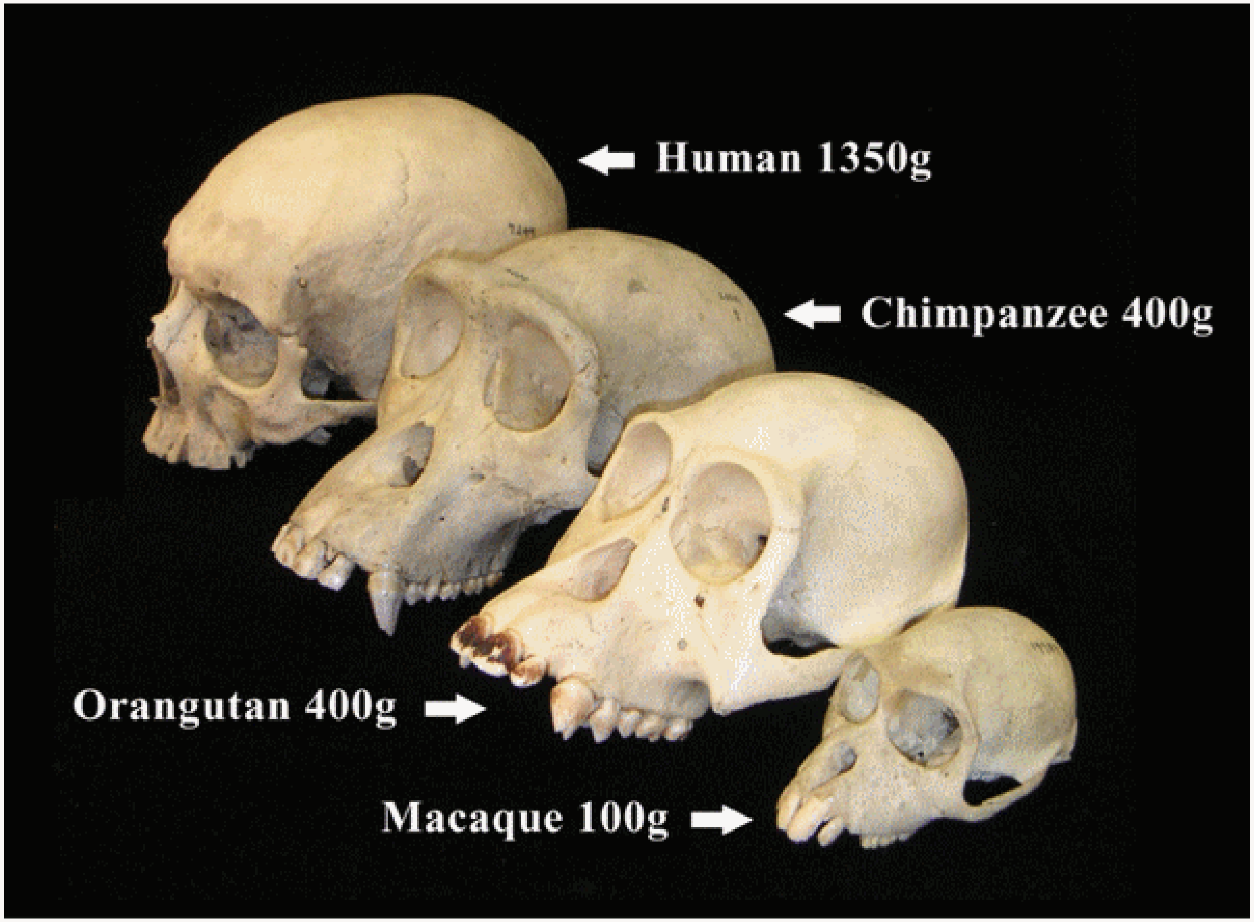


Representation of hominid evolution (greatly simplified)



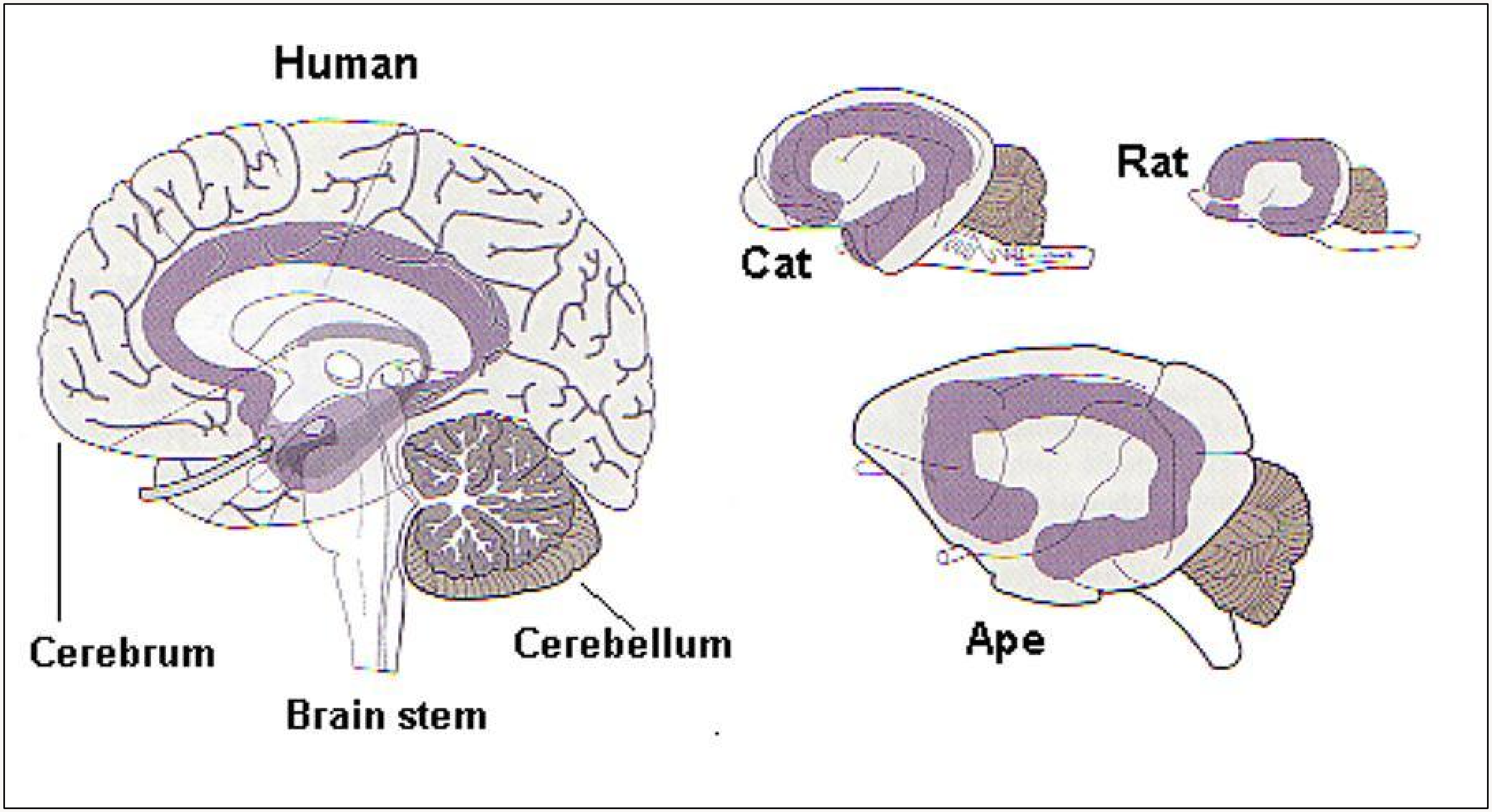
The evolution of *Homo* species was **not** a straight line. There were many sidelines with intermediate species breeding in different parts of Africa. Nonetheless, *Homo sapiens* is the only surviving member of the genus whose last dispersal out of Africa probably occurred about 70,000 years ago.

The human brain compared to other primates

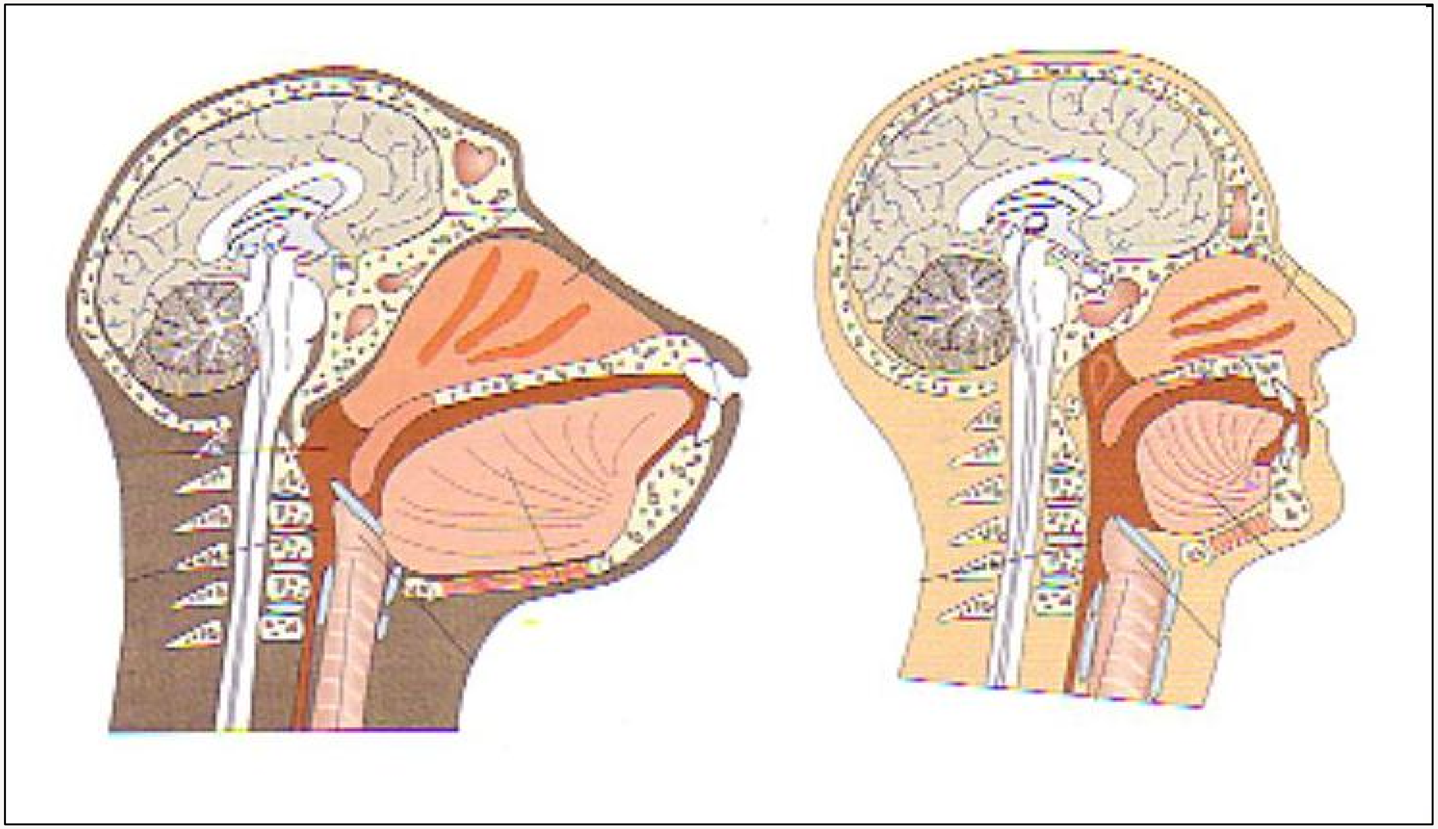


N.B. The relationship of brain size to cognitive power is not linear, though it is useful as an approximate guide. What is important is the size of the pre-frontal cortex (just behind the forehead).

The human brain compared to some common animals



Comparison of hominin skulls



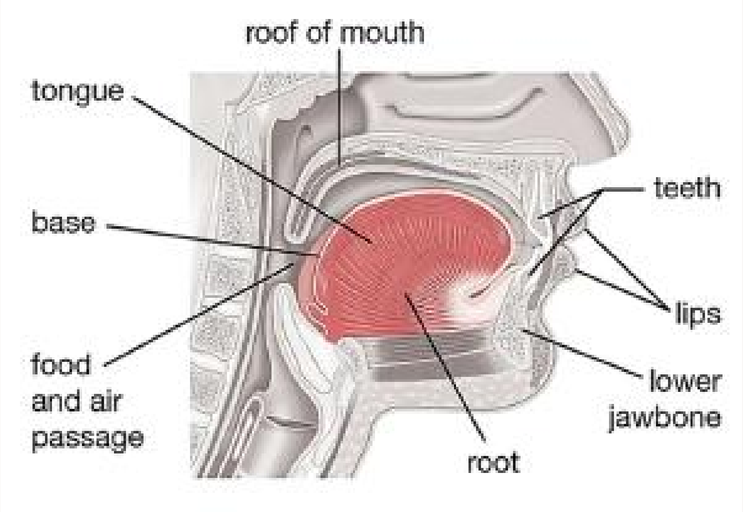
Note the larger cortex in humans and the shape of the oral-pharyngeal tract. The pharynx (throat) is longer, this helps in amplifying sound. The human mouth is shorter and the tongue is an agile, bunched muscle. The palate (roof of the mouth) is arched upwards with humans, providing more space for articulating vowels.

Additional function of the tongue with humans

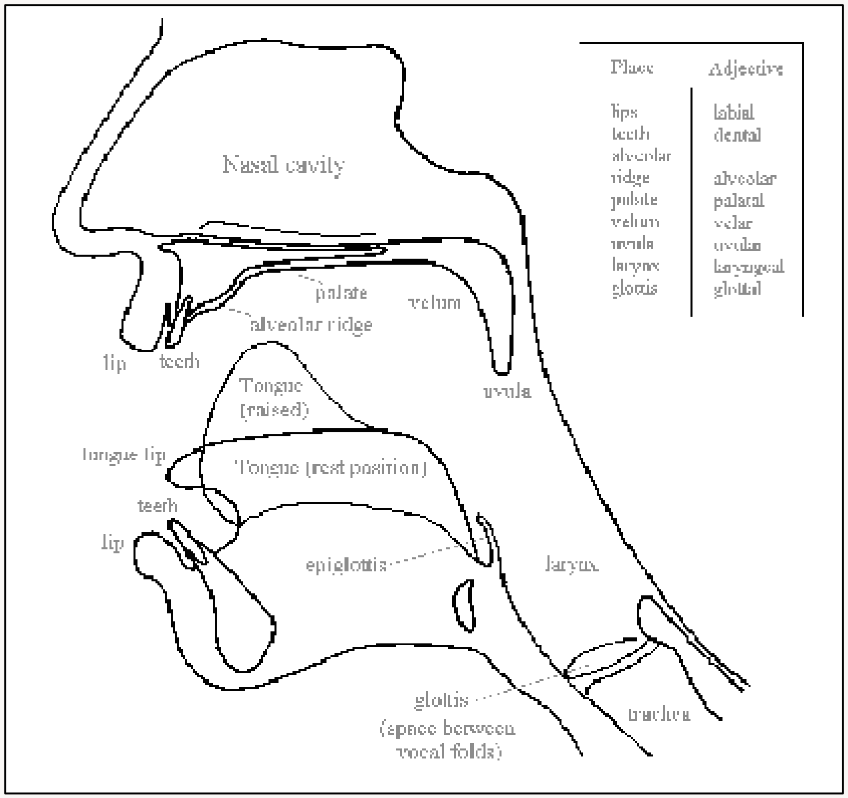
With most animals the tongue is used (i) to move food around the mouth when chewing and swallowing and (ii) to lose excess heat in hot weather (thermoregulation).

Humans, unlike other hominins, lost body fur and developed accrine sweat glands over the entire body, following on apocrine sweat glands in the armpits which they share with chimpanzees, for example. This development meant the human tongue was no longer used to dispose of excess body heat and lost its limp, flaccid character (compare it to dogs' tongues, for instance). It evolved into a tight bunched muscle capable of rapid and flexible movements for sound production. (This development may have been connected to a reduction in mouth size and jaw muscle strength when humans began to cook tough, fibrous food which requires less chewing when cooked.)

Incidentally, the loss of body fur with humans allowed them to engage in persistence hunting, chasing animal prey in the midday heat, because humans can sweat easily and pursued animals eventually collapse from heat exhaustion.



The human vocal tract



We use our organs of speech to realise the abstract elements in the phonology of our native language. The tongue is the most agile muscle in our body and central to the production of sound. The vocal folds in our throat can vibrate to produce voice.

Hearing and producing sounds

Given that the sounds of nature, the rustling of leaves, running water, etc. are in the range of human hearing, it is fair to assume that, all other things being equal, exobeings would have hearing in this range as well.

If exobeings had orifices like a human mouth for the intake of food and teeth-like structures to break off food and chew it, then they could use these for the secondary function of producing sounds.

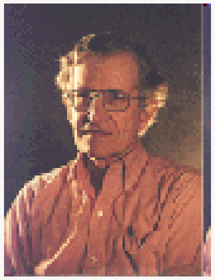
Consciousness and language

Before considering language, it is important to stand back for a moment and consider human consciousness, the seamless, first-person mental experience which permanetly accompanies our wakeful lives. It enables us to perceive and interact with the world around us and to register sensations.

The brain generates consciousness. Without the physical substrate of our brains we have no consciousness and if the brain ceases to function, consciousness instantly disappears.

This is part of a larger issue concerning the relationship of non-physical experiences and faculties to the physical biology of our bodies.

There are no simple answers here. The issue of consciousness would doubtlessly be as important for exobeings as it is for us humans.



Language on and beyond Earth

All humans possess a language faculty as part of their genetic endowment. This faculty allows humans to acquire any language they are exposed to in early childhood. The language faculty is an instinct: it begins to unfold when we are born. The stimulus it needs to operate is linguistic data which is provided by the surroundings of an infant. Importantly, no-one has to tell children to start using their language faculty – this happens automatically.

One of the major achievements of Noam Chomsky is to have highlighted our awareness of this faculty and to insist that it contains specifications for what is a possible human language. The range of structures which are permitted by the language faculty is called Universal Grammar. Each human language consists of a subset of these structures.

Exobeings, assuming they speak languages comparable to ours, will definitely have a language faculty.

How did the language faculty arise?

In the scientific community there is disagreement on this issue which can be summarised roughly as follows:

1) Continuity hypothesis: language evolved slowly during the lifespan of *Homo sapiens* over several hundred thousand years with no sudden breaks between generations.

2) Discontinuity hypothesis: around 100,000 years ago a ‘sudden rewiring’ in the brain of an individual led to the ability to have recursive hierarchical structures in syntax by virtue of the operation ‘Merge’; this ability then propagated throughout the relatively small community of *Homo sapiens* in East Africa before the last dispersal about 70,000 year ago.
This view has been propounded by Chomsky but has not attained widespread support in the community of linguists working on language evolution.

If the Discontinuity hypothesis is correct then for an exolanguage to be structurally comparable to human language a similar ‘rewiring’ must have taken place at some point in its history permitting complex syntax to arise.

What is language for?

This might seem like an odd question to ask. You might think: for people to communicate with each other, of course. However, the issue is not that simple.

Again we find differing views on this. Chomsky maintains that language evolved as an instrument for organising thoughts. Subsequently, it was "externalised", i.e. used for interpersonal communication, but that is only secondary. Not many scholars agree with this, though there are some philosophers of mind who do or did, like the late Jerry Fodor. This question has a direct bearing on how language arose. The issue can be formulated as two alternative questions:

1) Did language arise internally and then come to be used externally for communication?

Or:

2) Did language arise in external exchanges and later come to be internalised?

Chomsky favours (1) as it allows the rise of syntax independently of any external contingencies of time. A simple example would be: *Fiona made herself some coffee after she had a shower*. Clearly the temporal sequence of events is (1) shower, then (2) coffee, which is the opposite of the sentence. So the syntax of human languages is not bound to the temporal sequence of events. Not now, it may, however, have arisen in this bounded fashion.

The language instinct

Language as an instinct, as an innate faculty

An instinct is a tendency to do something which, when triggered in childhood, cannot be ignored or rejected, it is not a matter of conscious decision. The development of an instinct takes place immediately after birth and is completed quickly.

If one applies this view to language acquisition then one can maintain the following.

1) No child makes a conscious decision to learn a language.
2) No child ever refuses to learn the language spoken in their environment.
3) Acquisition is unconscious and can be compared with the unfolding of other instincts, for instance that of binaural hearing or telescopic vision.

Linguists furthermore assume that we know what language is and how we are to react to it, i.e. by acquiring it. To put it simply: the language faculty is innate so that the children can immediately process the language they hear in the surroundings. Children must not wait for instructions from their parents before acquiring their native language.

Sign language: an alternative modality

The evidence of deaf children

Deaf children start by babbling and cooing but this soon peters out because they have no linguistic input. However, they would seem to seize on other communication systems and if people in their surroundings use sign language then they pick this up. The interesting point here is that the children usually learn the sign language more perfectly than the people they learn it from (sign language has grammar with inflections just as spoken language does). They are creative in this language and construct sentence structures if these are not present in their input. This would seem to suggest that deaf children use sign language as a medium for externalising their innate knowledge about language.

Stages in language acquisition

0.0 - 0.3	Organic sounds, crying, cooing
0.4 - 0.5	Beginning of the babbling phase (practising the production of sounds)
0.10 - 1	The first comprehensible words. After this follow one-word, two-word and many-word sentences. The only word stages is known as the holophrastic stage; Telegraphic speech refers to speech with only nouns and verbs.
2.6	Inflection occurs, negation, interrogative and imperative sentences appear.
3.0	A vocabulary of about 1000 words.
5.0	The main syntactic rules have been acquired. Children are completely fluent in their native language.
6.0 —	More complex syntactic structures are acquired. As an open class, vocabulary continues to expand all your life.

N.B.: These stages apply to all human languages irrespective of their structure and their formal complexity.

What we know about language

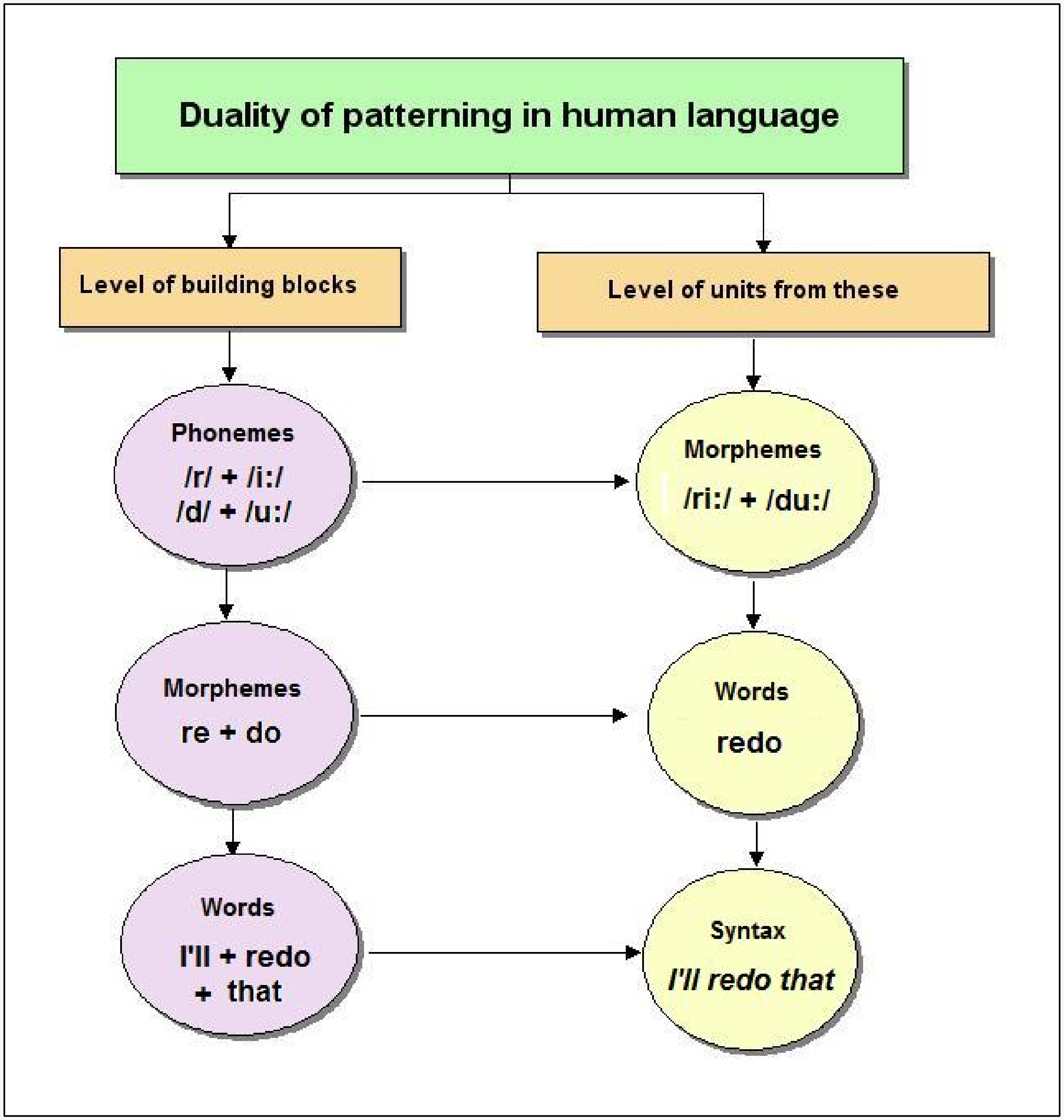
Unconscious knowledge

For the linguist the metaphor of the iceberg can be useful: nine tenths of our knowledge of language is under the surface. For instance, I take it that few if any people would be in a position to list and describe the sentence structures of their native language. Nonetheless, they use these hundreds of times each day in well-formed sentences.

This helps us to recognise that there are two types of knowledge: knowledge which one can express in words - e.g. the rules of chess - and unconscious knowledge which is activated without reflection, for instance, when speaking your native language. Such unconscious knowledge is based on the internalisation of language structures which we extracted from language we heard as young children.

Input		Language in our surroundings
Action by child	(i)	extraction of structures
	(ii)	storage in long term memory as unconscious knowledge

Duality of patterning renders language more efficient



Cognitive categories in language

Word classes

These are sets of words defined by the role they can play in a sentence

Major word classes

Nouns —— refer to objects, ideas, feelings, concepts, etc.
Verbs —— refer to states or actions

Minor word classes

Determiners —— include articles and pronouns of various kinds
Adjectives —— qualify a noun
Adverbs —— qualify verbs or parts of a sentence

Prepositions —— express relations between major word classes

Conjunctions —— link up parts of a sentence

Getting a handle on an exolanguage

Deciphering an exolanguage would present a series challenges. Apart from the question of how it is manifested (as sounds of some sort) there is the issue of internal structure (what kind of syntax would it have) and not least the matter of semantics (what kinds of meaning categories would it have and how would these be reflected in the form of the language). Could we assume that the experience of their planetary environment would result in cognitive categories which would be expressed in exolanguage using particular units (word classes) as in the following table.

Cognitive categories and their possible expression in language

Cognition	*Language*
objects	nouns
qualifiers	adjectives
actions	verbs
qualifiers	adverbs
spatial relations	prepositions (or similar elements)

Reflecting on the world we / they life in

Word classes and exolanguages

The word classes just outlined on the previous slide are closely bound to the space-time environment we live in. The two major word classes, nouns and verbs, reflect the spatial and the temporal aspects of our existence respectively. Furthermore, we know that objects and actions vary in size, type, extent, etc., hence our use of qualifiers like adjectives and adverbs.

Exobeings on their planet would experience space and time similarly to us Earthlings as we know the (observable) universe is uniform in this respect. The manner in which they experience space and time might differ, of course. Their planet might be bigger or smaller than ours, they might lead shorter or longer lives than we do. But it is safe to say that the word classes and vocabulary of an exolanguage would mirror the environment of the exobeings who speak it.

Could we communicate with exobeings?

Reconnecting with the question of this presentation we can say:

1) To understand the communication system of exobeings (an exolanguage) it would have to show a modality (sound or signing) which we could, in principle, interpret. This would presuppose that exobeings have an equivalent to our vocal tract (for sound in our hearing range) and limbs similar to our hands (for signing).

2) Considering how exolanguages might arise, how they might be structured and organised, their relationship to cognition, their use for communication in exosocieties, the manner in which they would change across space and time would help us engage successfully with exobeings and in addition lead to insights for linguistics and make the investigation a worthwhile endeavour for us to undertake, should we ever be confronted with one or more exolanguages.

Thankyou.