Introduction: What is Cognitive Science?
Cognitive science is the interdisciplinary study of mind and intelligence

- philosophy
- psychology
- neuroscience
- artificial intelligence
- linguistics
- anthropology
History of cognitive science: preliminary remarks

Fundamental philosophical questions since Aristotle and Plato:
1. What is the nature of mind? Metaphysics and nature of reality
2. What is the nature of knowledge? Epistemology and nature of knowledge

Psychology: 1890s. Behaviorism: can’t study what is in the mind
(from "philosophical psychology" towards "experimental psychology")
1950’s. Miller, etc.: mind has structure
3. How do we think?

Neuroscience:
4. How does the brain make a mind?

Artificial intelligence: 1956. Minsky, Newell, Simon, McCarthy
5. How to construct mind?
6. Innateness?

Anthropology: social, cultural aspects of knowledge
7. Is there any cultural difference in the thinking of people?

The need of integration:
How can all these fields, with different histories and methodologies can be integrated to produce an understanding of mind?
Key concepts

Mental representation
Computational procedures

Thinking = Mental representations + computational procedures

more precisely:

Thinking = representational structures + procedures that operate on those structures.

Analogy between computation and thinking:
data structures  mental representations

+ algorithms  + procedures

= running programs  = thinking

Methodological consequence: study the mind by developing computer simulations of thinking
Philosophy

from the Greek philosophers to the "age of reason"

Aristotle: logical inference; knowledge from experience" "rule-based knowledge"
Plato: What is knowledge? "concepts are innate"

**rationalism**: Plato, Descartes, Leibniz:
knowledge can be gained by thinking and reasoning

**empirism**: Aristotle, Locke, Hume:
learning be experience

Further reading: http://plato.stanford.edu/entries/rationalism-empiricism/

Kant: combination of rationalism and empirism
Philosophy

The brain - mind problem

- monism vs. dualism
- reductionism
- emergentism
- functionalism
- downward causation
Monism versus dualisms

Monism:

is the theory that there is only one fundamental kind, category of thing or principle.

Dualism:

is the theory that the mental and the physical or mind and body or mind and brain are, in some sense, radically different kinds of thing.

(Interactionist dualism from Descartes to Popper and Eccles)
Reductionism

Complex things can always be reduced to (explained by) simpler or more fundamental things.

Ontological reductionism $\leftrightarrow$ monism

Denial of reductionist ideas is holism
Emergentism

Emergentism is a theory concerning the nature of the material world. In contrast to reductionistic materialism, which asserts that only the tiniest components of matter have unique properties, emergentism maintains that along with complexity, and especially with structure and function, go properties that are unique and that are not to be found in the tiniest components of matter. These properties of more complex systems are therefore not reducible to those of their constituent elements, though they could not exist without them. While many of the fundamental properties of matter, such as mass, are held to be merely quantitative and additive, emergent properties are said to be qualitative and novel or non-predictable.
Functionalism

Functionalism is the doctrine that what makes something a thought, desire, pain (or any other type of mental state) depends not on its internal constitution, but solely on its function, or the role it plays, in the cognitive system of which it is a part. More precisely, functionalist theories take the identity of a mental state to be determined by its causal relations to sensory stimulations, other mental states, and behavior.
Downward Causation

all processes at the lower level of a hierarchy are restrained by and act in conformity to the laws of the higher level (Donald T. Campbell)
Specifically:
mental agents can influence the neural functioning (R. Sperry)

"Two way causation"

The whole is to some degree constrained by the parts (upward causation), but at the same time the parts are to some degree constrained by the whole (downward causation). The nervous system can be considered as being open to various kinds of information, and that there would be no valid scientific reason to deny the existence of downward causation, or more precisely, a two-way causal relationship between brain and mind (Szentágothai)

more reading:
http://pespmc1.vub.ac.be/DOWNCAUS.html
Psychology

George Miller:
The Magical Number Seven, Plus or Minus Two:
Some Limits on Our Capacity for Processing Information (1956)
http://www.well.com/user/smalin/miller.html

Short-term memory could only hold seven plus or minus two chunks of information
a chunk is any meaningful unit:
digits, words, chess positions, or people’s faces

The concept of chunking and the limited capacity of short term memory became a basic element of all subsequent theories of memory.

finite capacity of human thinking
"information processing"
Memory models
Neuroscience

- Experimental methods and disciplines
- Levels
- Neural representation: cells, networks, modules
- Neural computation versus computational neuroscience
- Cognitive Neuroscience
Artificial intelligence

John McCarthy coined the term "artificial intelligence": Dartmouth Conference, the first conference devoted to the subject (1956)

- the first running AI program, the Logic Theorist (LT): Allen Newell, J.C. Shaw and Herbert Simon (1957)

- The General Problem Solver (GPS) demonstrated by Newell, Shaw and Simon. 1952-62

- first game-playing program, for checkers, to achieve sufficient skill to challenge a world champion: Arthur Samuel 1958

- LISP language: John McCarthy: 1958
• Teddington Conference on the Mechanization of Thought Processes: UK John McCarthy’s "Programs with Common Sense," Oliver Selfridge’s "Pandemonium," and Marvin Minsky’s "Some Methods of Heuristic Programming and Artificial Intelligence."; 1958

LISP: model of functional programming language
Linguistics

Noam Chomsky versus behaviorist view of language.

Innateness: universal grammar

- rejected behaviorist assumptions about language as a learned habit

- proposed instead to explain language comprehension in terms of mental grammars consisting of rules

- generative grammar

- Syntactic Structures 1957
Anthropology

Ethnography, but pay attention to how people think
Like psychology, but less experimental, more cross-cultural

Psychologists are also doing cross-cultural studies