Artificial Intelligence is over 40 years old. It has resulted in some smart computation but has revealed very little about the operation of the brain. In recent years AI researchers have attempted to put this right and have specifically concentrated on modelling the brain to try to reveal what mechanisms are essential for human and animal consciousness. In our own work we have discovered that several mechanisms are involved in making us conscious. These computational mechanisms create a 'self' in a perceived world, ensure internal states as a basis for imagination, attend to important features of our world, plan and exhibit life-preserving emotions. This leads to a clarification of many issues surrounding consciousness. Are animals conscious? What is the unconscious? What is free will? Because emotions are present in these computational models, it may well be that a machine will be built that enjoys Christmas.

British Computer Society, Oxfordshire

Christmas 2006

The Machine That Enjoys Christmas: Whither Machine Consciousness?

Igor Aleksander FREng
Emeritus Professor of Neural Systems
Department of Electrical and Electronic Engineering
Imperial College, London

ENJOYING

EMOTION

BEING CONSCIOUS

WHY MACHINES?

UNDERSTANDING BY BUILDING

SOME EMOTIONAL ROBOTS

AI – Spielberg (Kubrick)

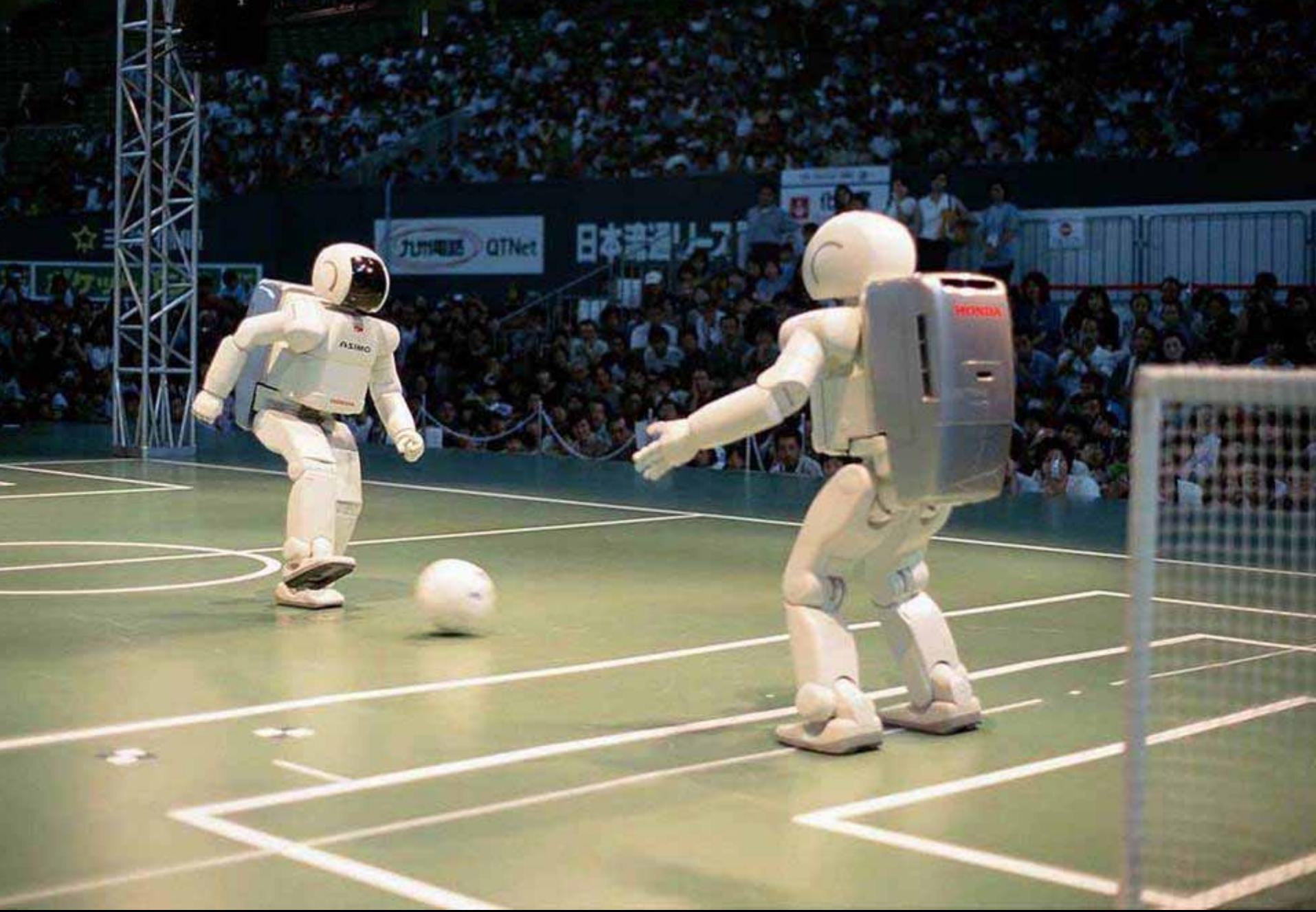
David (Haley Joel Osment) Gigolo (Jude Law)

2002

Jewish Folk History: The Golem

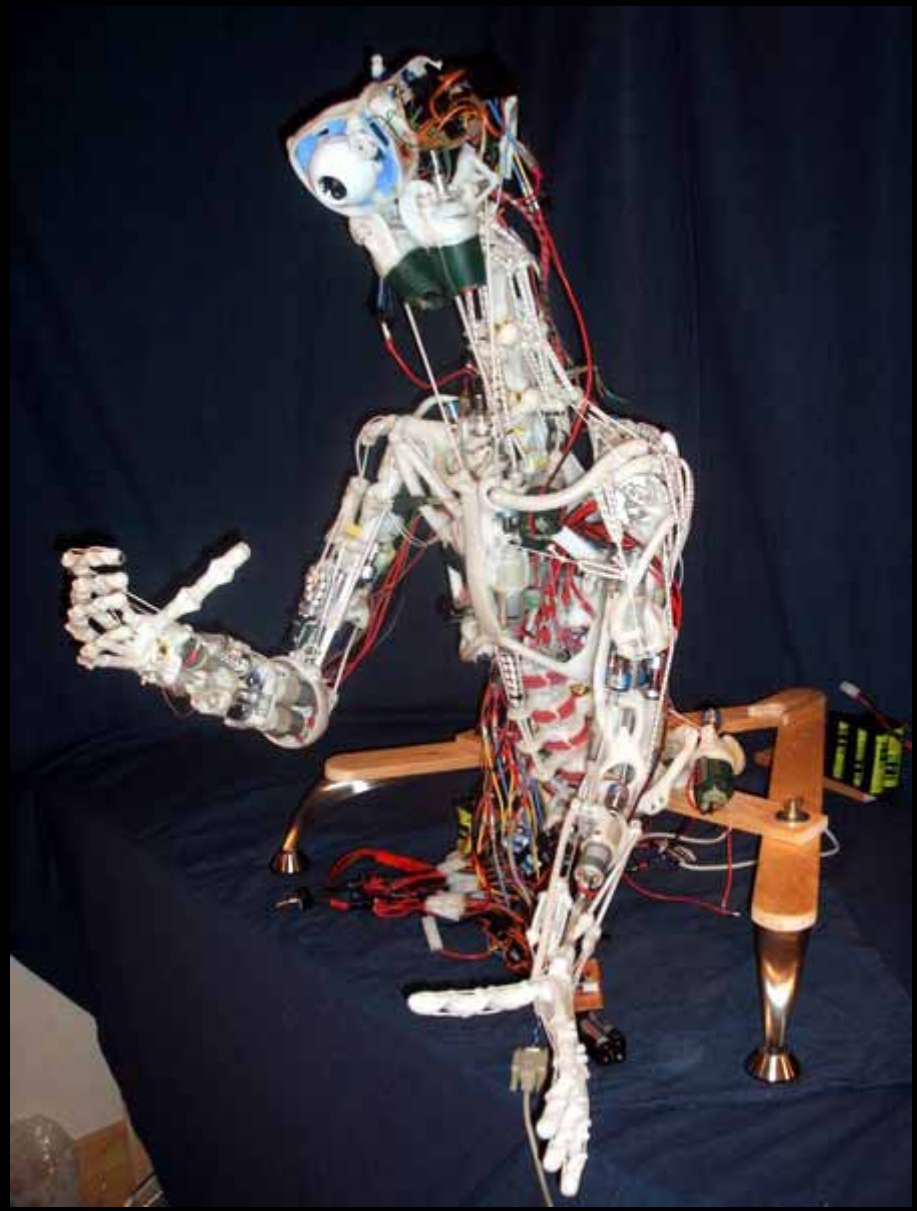
1920

SOME REAL ROBOTS



Honda’s ASIMO

SOME EXCEPTIONS



Owen Holland's CRONOS: £500K EPSRC grant for 'Machine Consciousness'

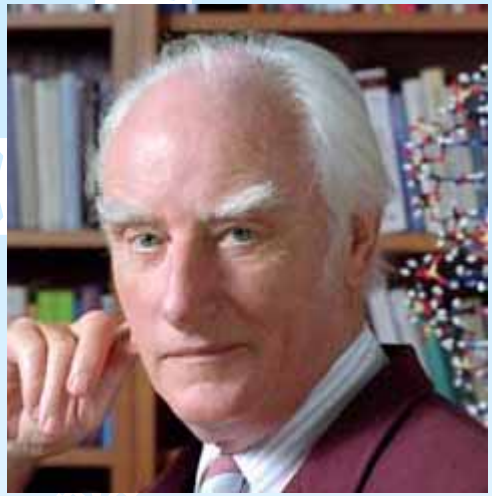
Cynthia Brezeal & Kismet - MIT

Cynthia Brezeal & Kismet - MIT

Why do we find it so hard to think of a machine as being conscious?

1. We are only SURE of our own consciousness.
2. We attribute it to other humans or optionally to other animals. Plants …?
3. We are not sure what consciousness is, let alone how to instil it into a machine.

Sir Francis Crick
1916 - 2004



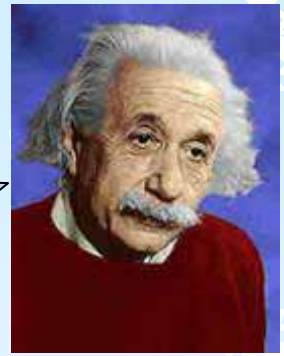
Crick's 'Astonishing Hypothesis' *Paraphrased*

"All our joys, sorrows, loves, hates, appreciation of the world, literature and good wine … … are a function of the two fistfuls of porridge we call our brain ."

Vesalius 1542

HOW DOES THE BRAIN CREATE MIND?

From Philosophy to the Frontiers of Science



SOCRATES
PLATO
ARISTOTLE
AUGUSTINE
AQUINAS
DESCARTES
ANN ARCHIVE
n Deutsch
LOCKE
HUME
KANT
WITTGENSTEIN
Hulton Deutsch
Hulton Deutsch
of the City of New York/Archive
DAMASIO
SEARLE
DENNETT
PENROSE
GREENFIELD

Certainly Not!

The engineering task:
understanding through building

Menu

What do some words mean?
The fast digital neuron
A kernel architecture
The depictive axioms
A demo
Some important questions

THE CONSCIOUS MIND:
Defining some slippery concepts

Being Conscious:

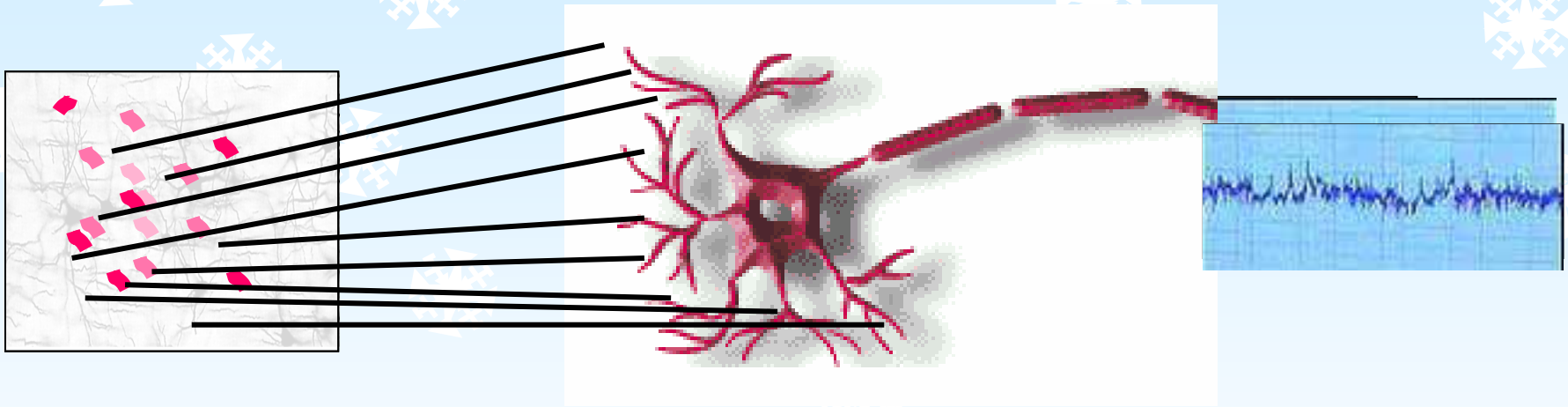
Thought:

Sensation:

THE MIND

The capacity for conscious thought that can occur in one person

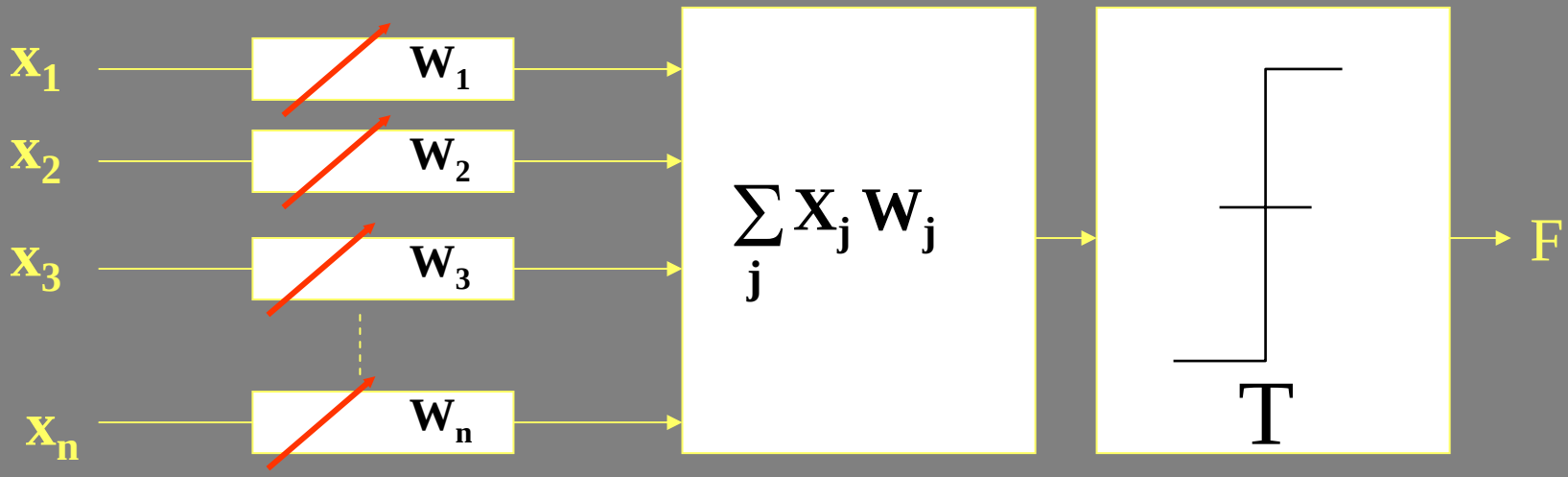
WHAT DOES A SINGLE NEURON DO?



The Classical 1943 McCulloch and Pitts Neuron Model

What were they modelling?

What are the elements of this model?



F=1 iff $\sum_j x_j w_j > T$

The Classical 1943 McCulloch and Pitts Neuron Model

Wh

Wh

x_1

x_2

x_3

x_n

F

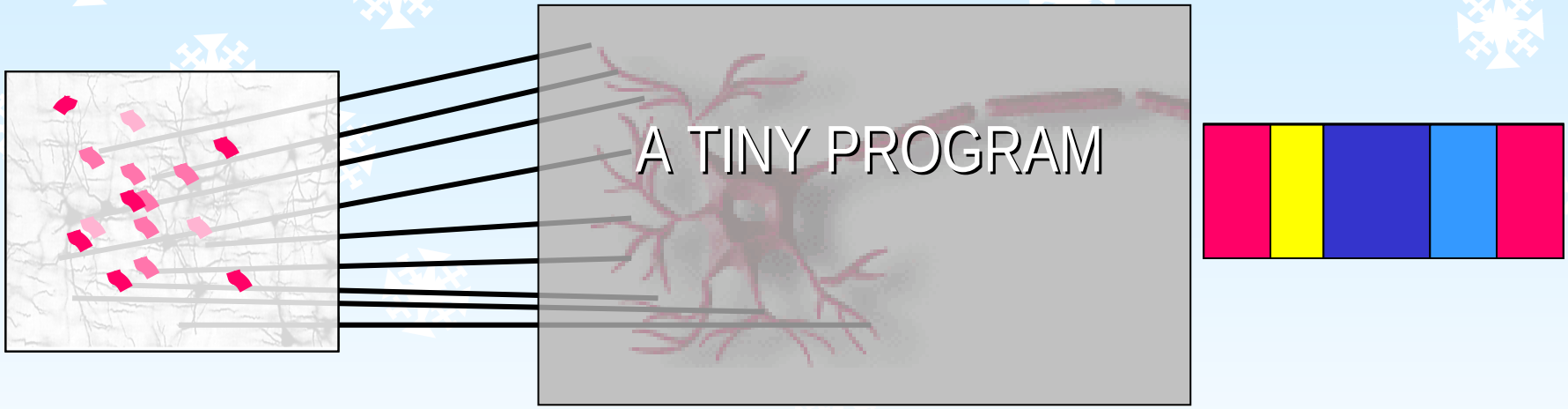
THIS IS NOT WHAT WAS DONE TO CREATE A COMPUTATIONAL NEURON

F=1 iff $\sum_j x_j w_j > T$

WHAT DOES A SINGLE NEURON DO?

IT LEARNS TO RECOGNISE PATTERNS

(AND TOLERATES LITTLE CHANGES)



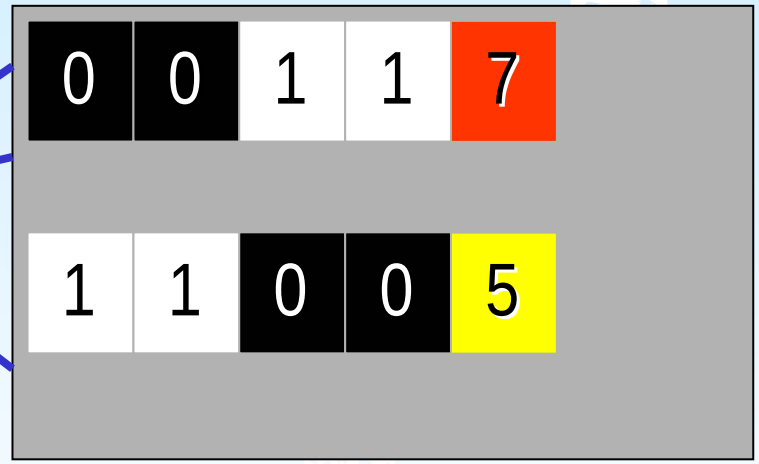
TOWARDS A DIGITAL SIMULATION

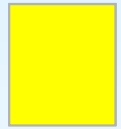
Input Pattern 2

Input Pattern 1

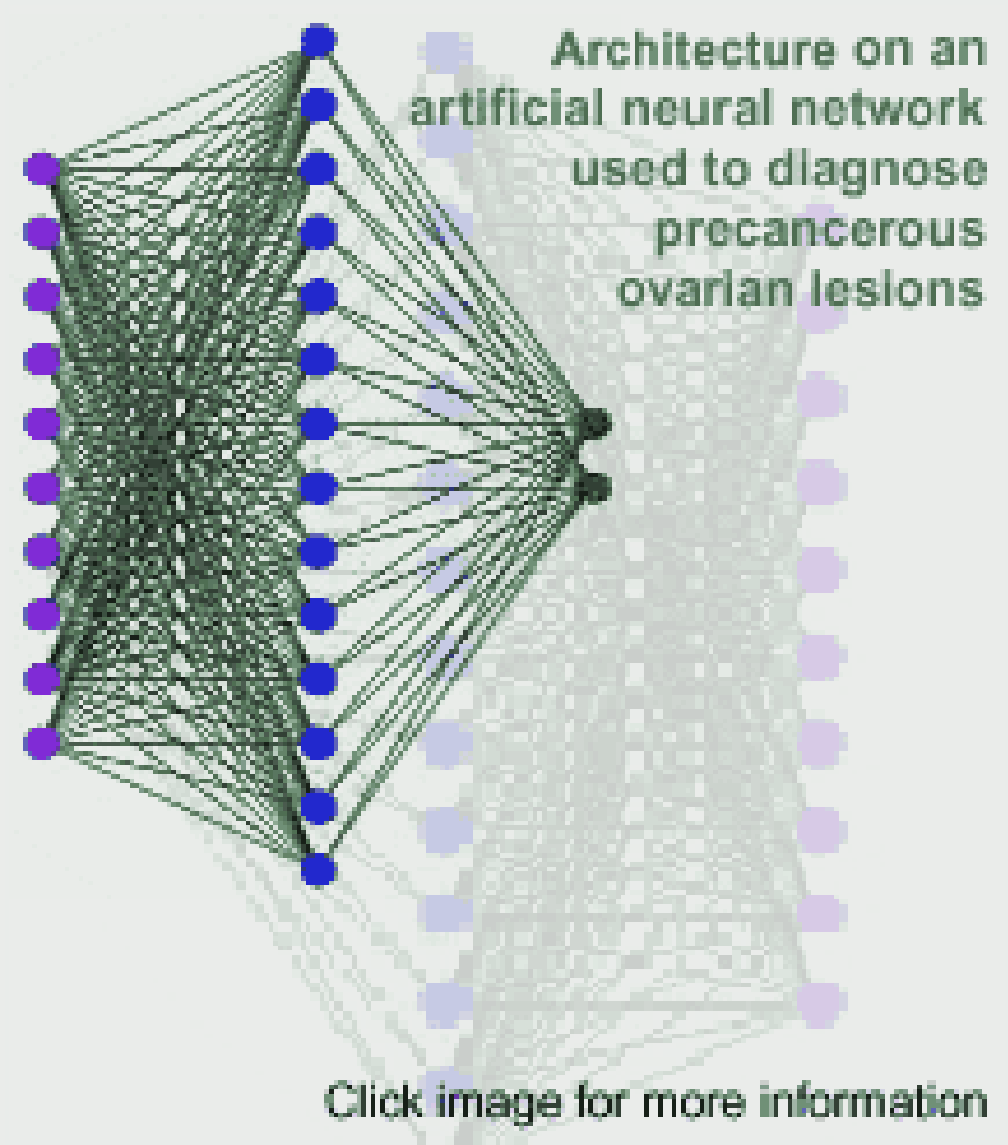
Unknown Pattern

A TINY PROGRAM





Artificial Neural Networks Label Complex Events



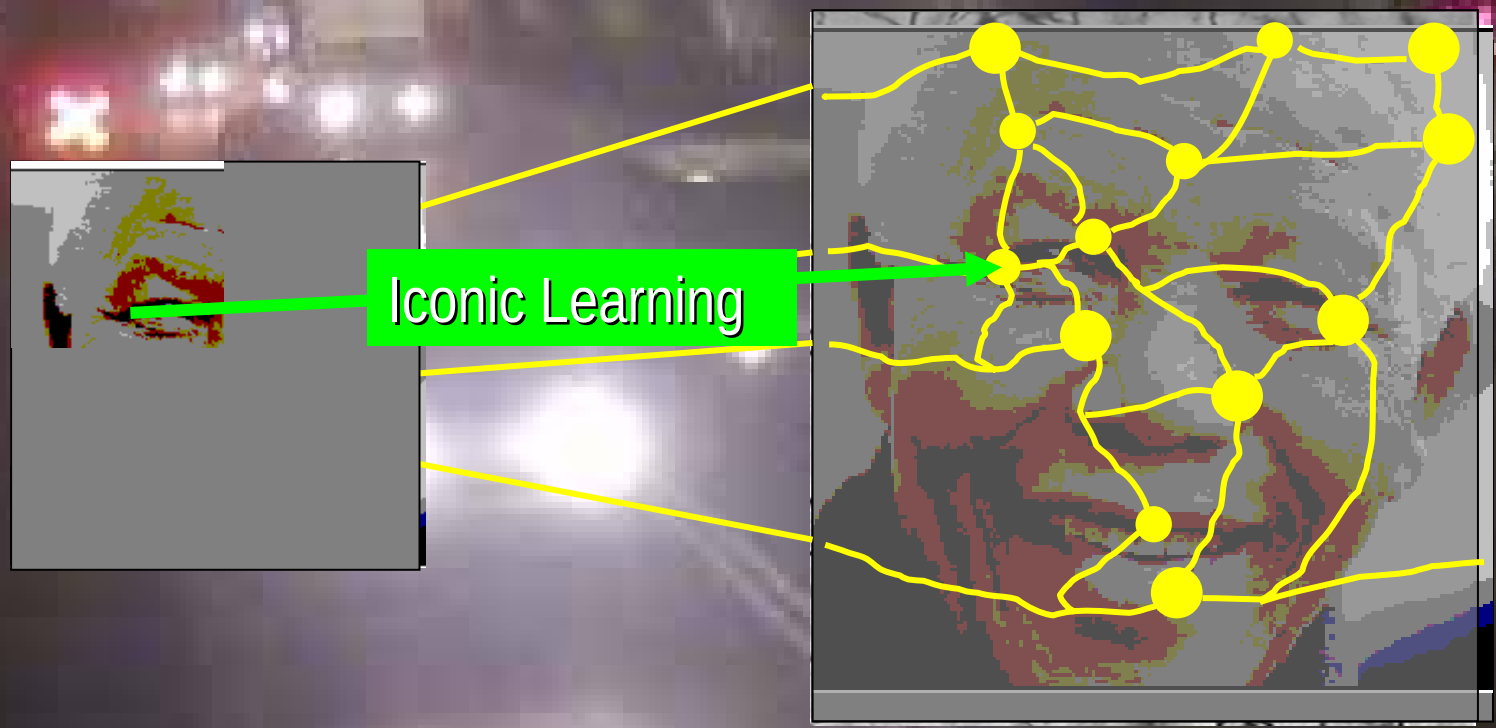
1968 A WORRY……

Q: HOW CAN A NEURAL NETWORK (A BRAIN) KNOW WHAT THINGS LOOK LIKE?

NEURONS MUST INTERCONNECT TO FORM A COHERENT, DYNAMIC GROUP

SUCH A NETWORK CAN *DEPICT* KNOWLEDGE AND RECALL IT GIVEN TINY CUES

Communicating neurons: memory and imagination



Let's try to design a conscious machine!

(the constructive approach)

DEFINITION ?

No definition

Try introspection …

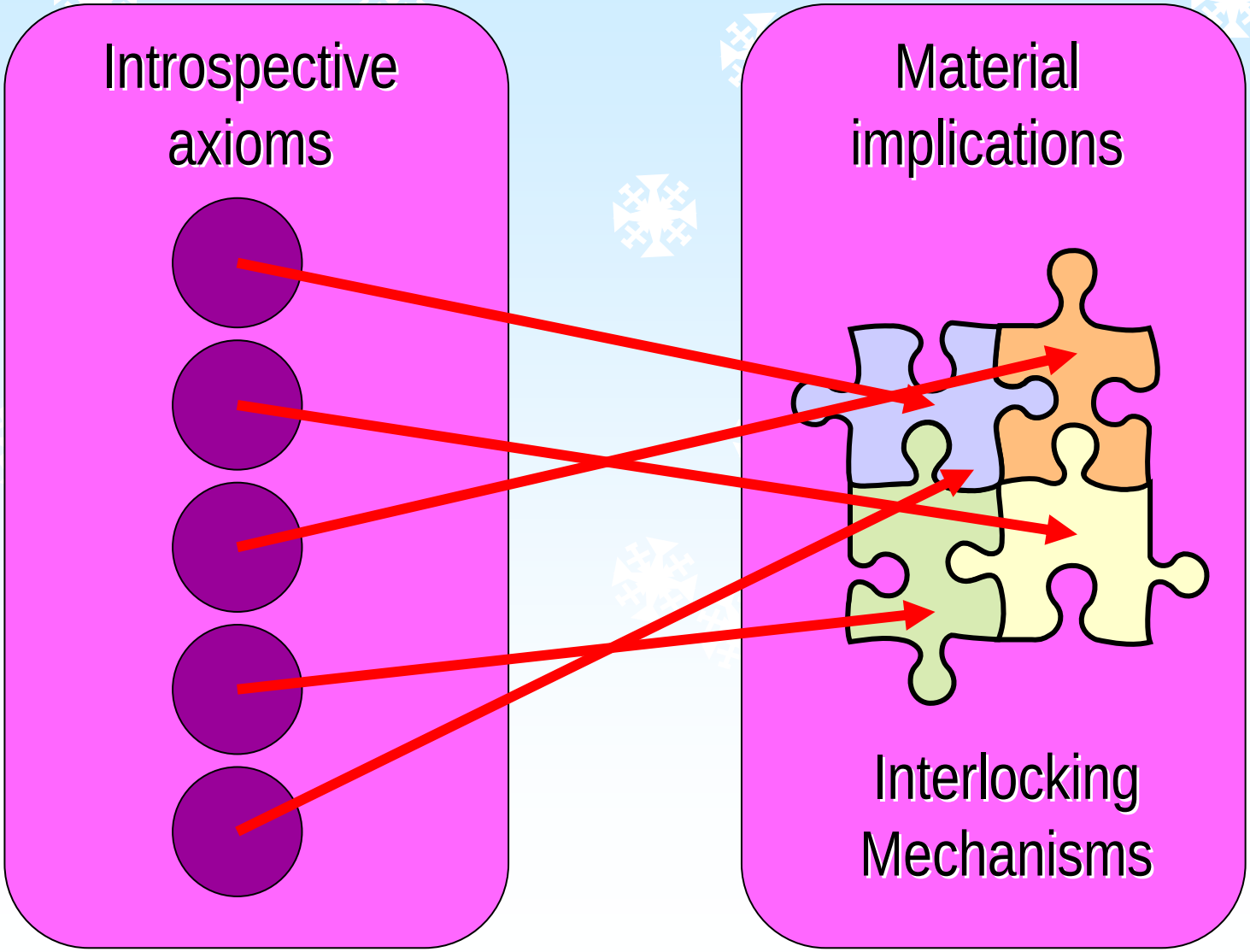
tells us that consciousness is lots of things.

We’ll see five (called axioms).

What Axioms? (5 distinct ways in which I feel conscious)

1. PRESENCE: I feel in the middle of an out-there world.
2. IMAGINATION: I can imagine worlds I have and have not perceived.
3. ATTENTION: I focus on what is important to me
4. VOLITION: I can decide what to do next
5. EMOTION: I evaluate options open to me.

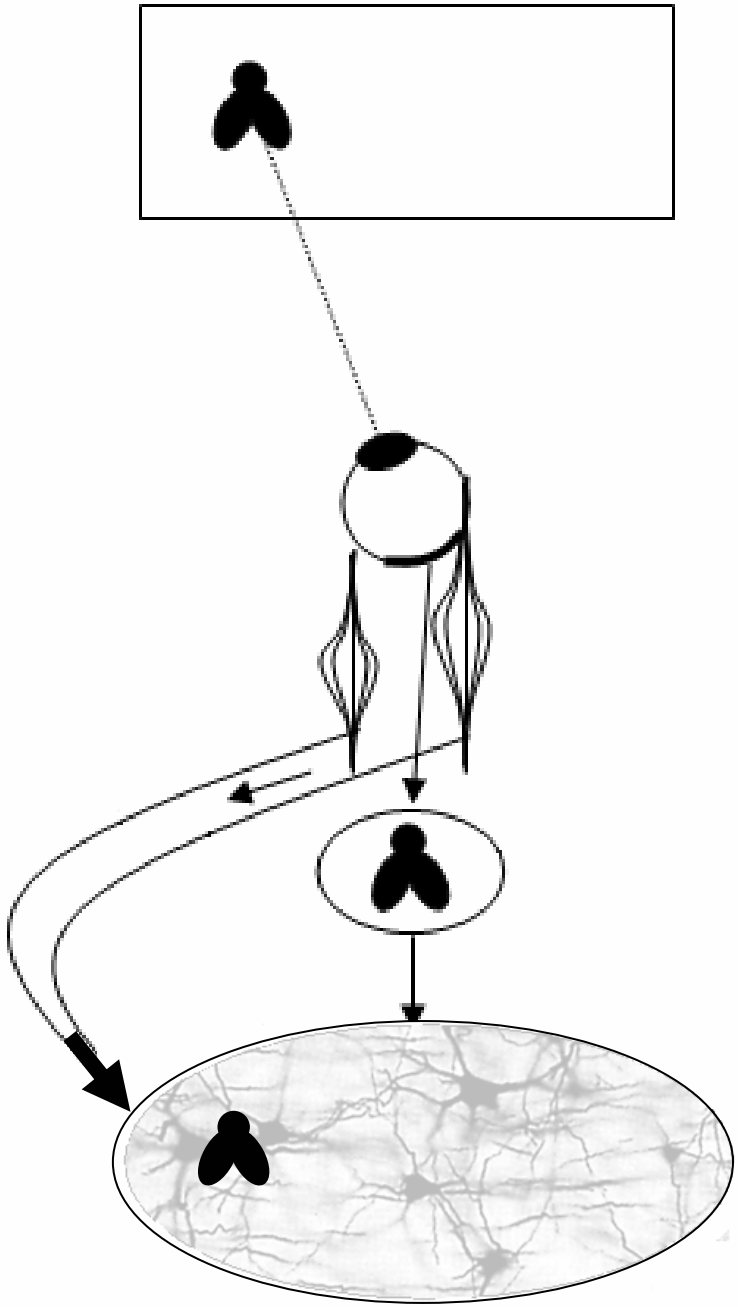
WHAT USE ARE INTROSPECTIVE AXIOMS?



What is a DEPICTION?

A representation of where things are in the world

Simple visual depiction



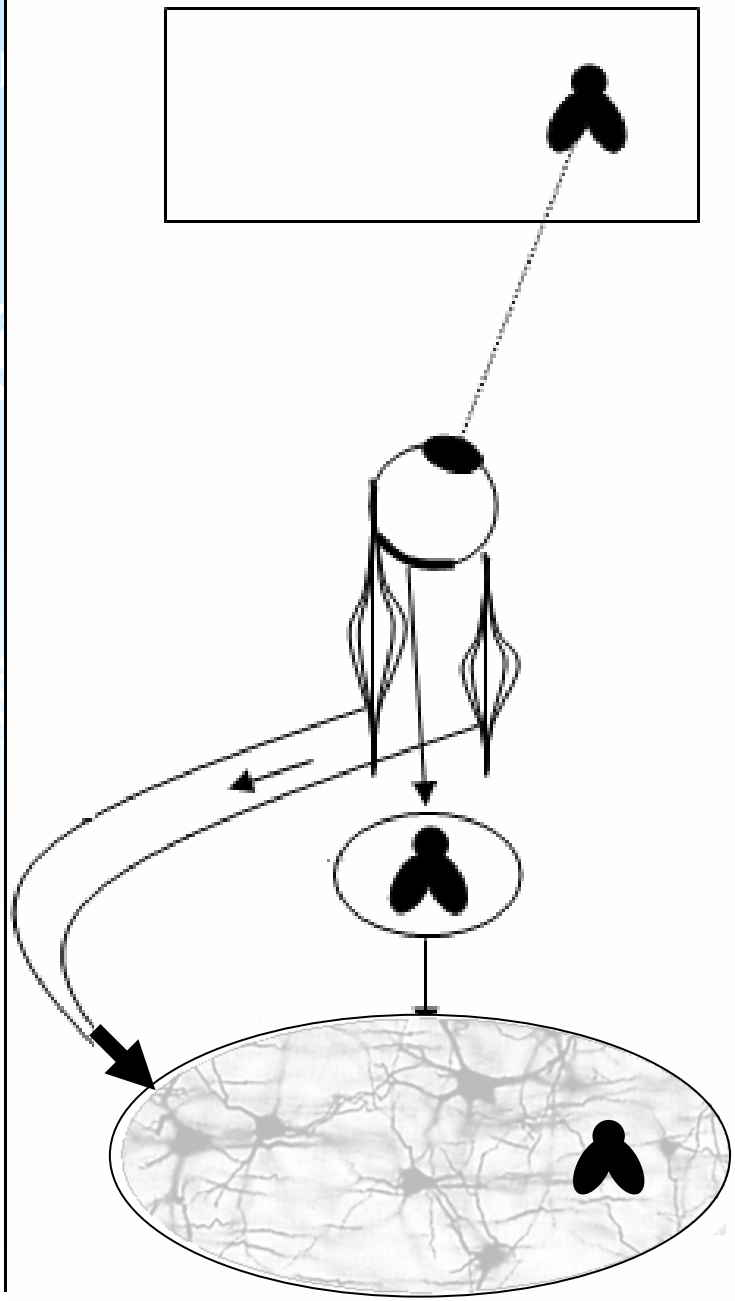
Fly in the world

Eye and muscles

Retinal image

Neural depiction

Simple visual depiction



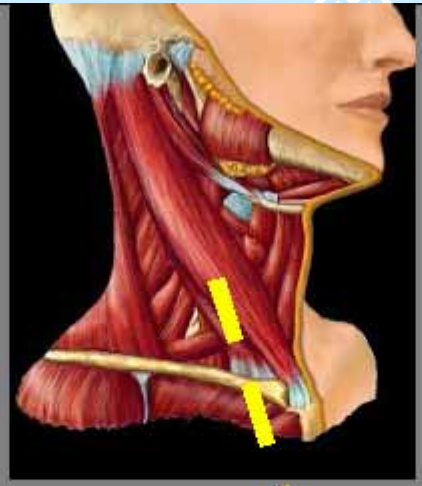
Fly in the world

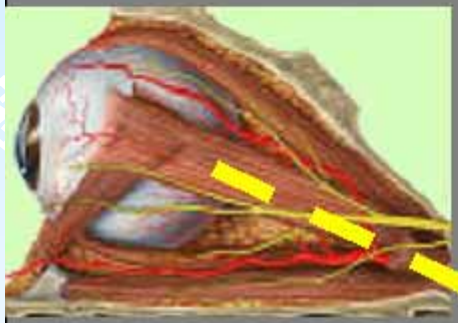
Eye and muscles

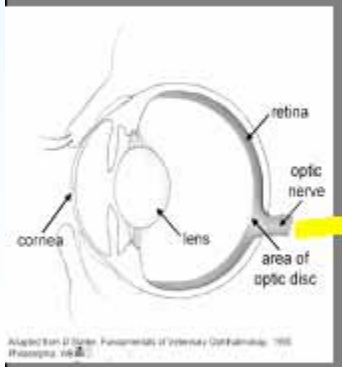
Retinal image

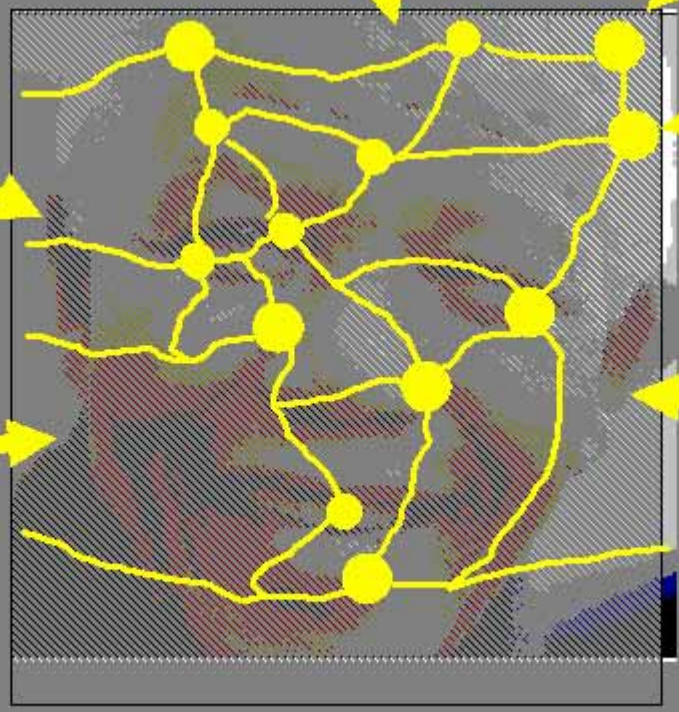
Neural depiction

What Creates Presence?

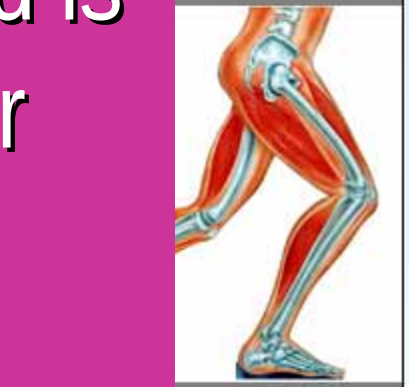








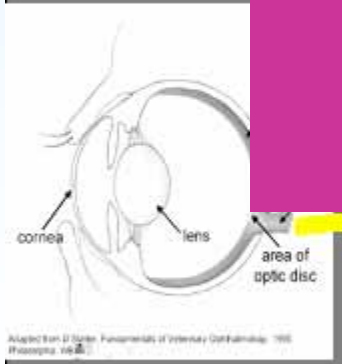
What Creates Presence?

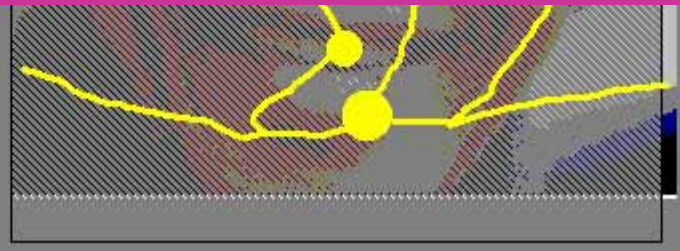


Answer:

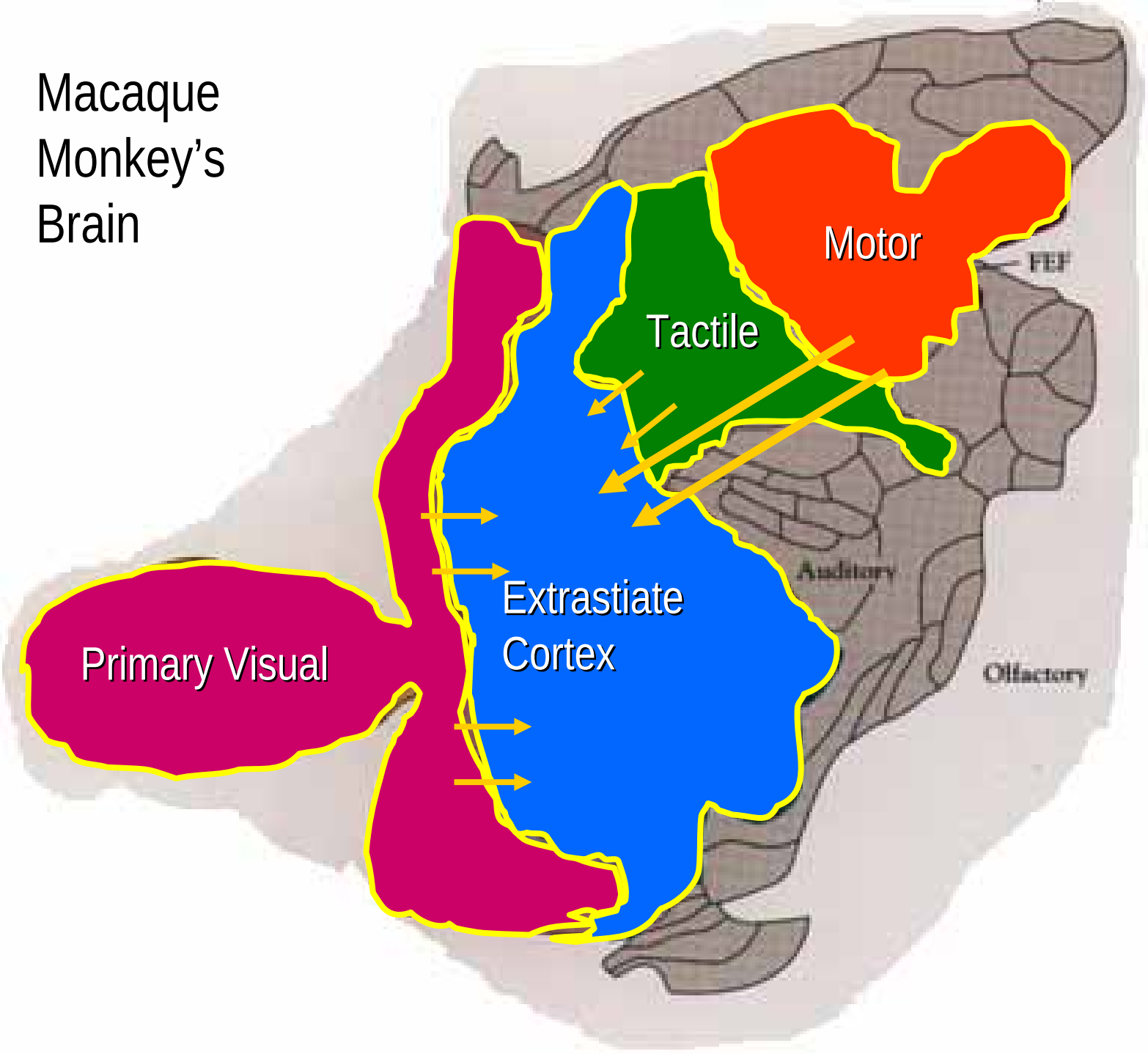
Presence in an out-there world is due to the influence of motor actions on sensory neural representations.

Does it happen in the brain?

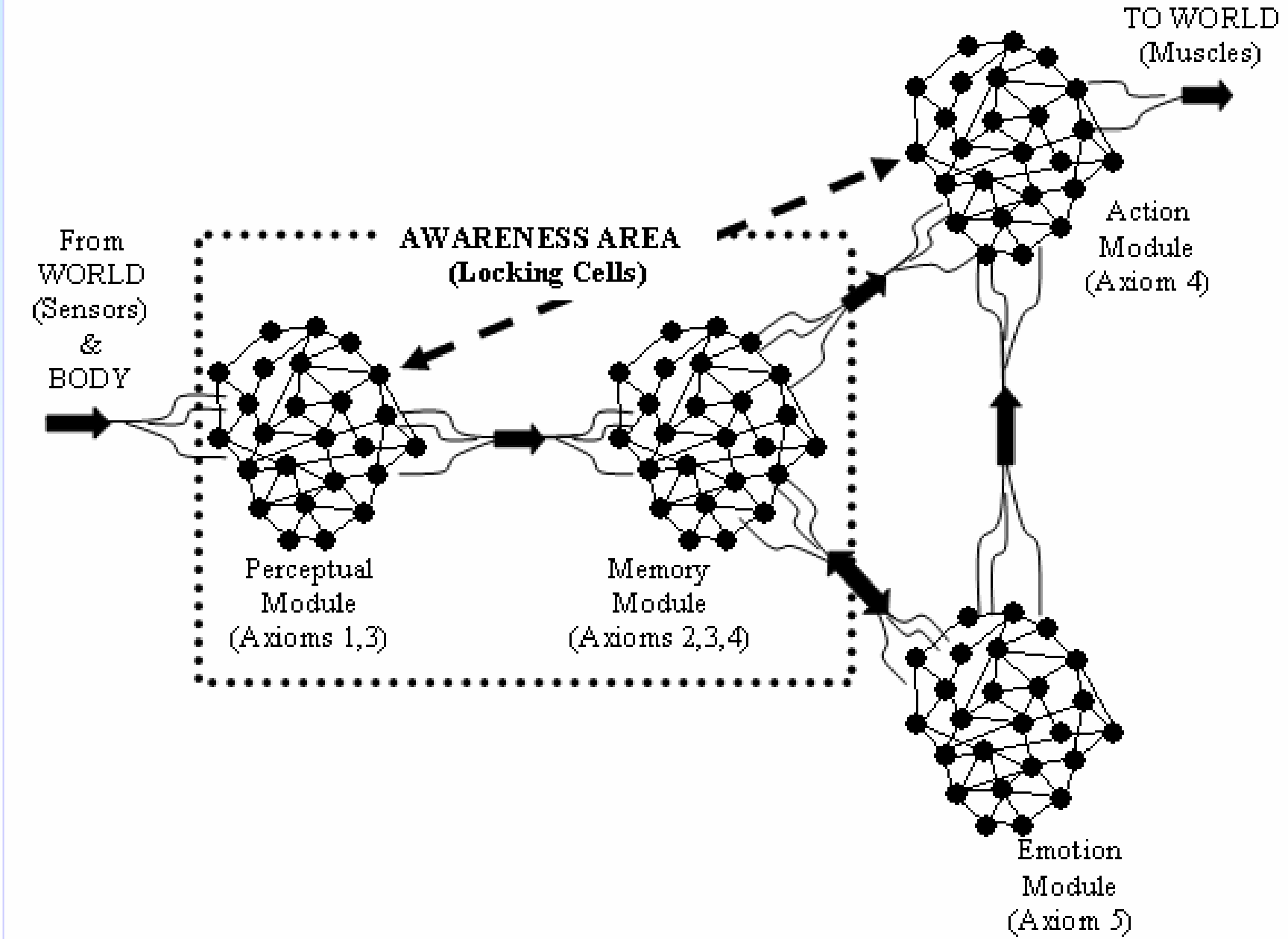




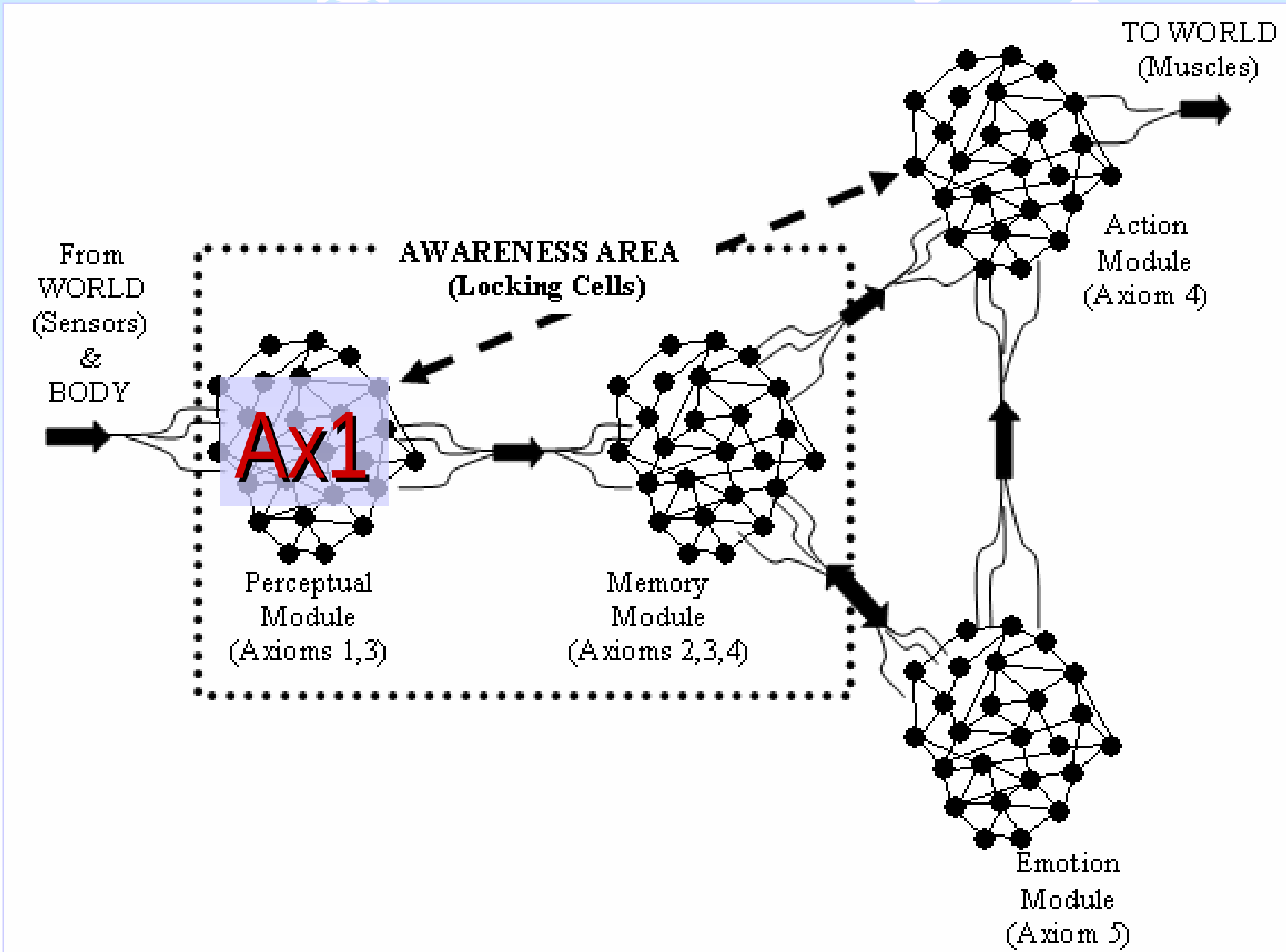
Macaque Monkey's Brain



(2004): A 'kernel architecture' capable of supporting the five axioms:

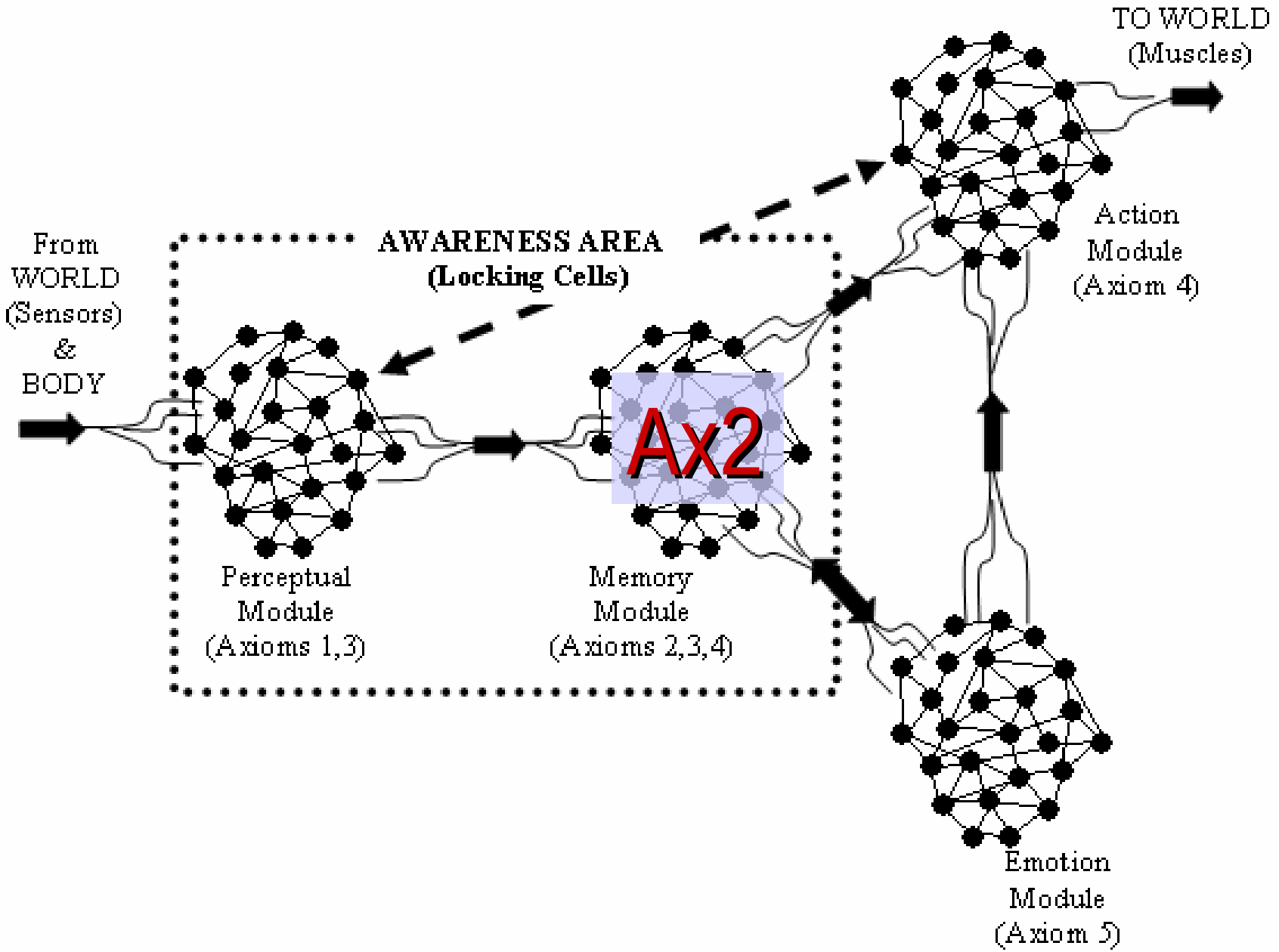


1. Presence: feeling a self in the ‘out-there’: Accurate cellular depiction indexed on muscular data of (say) eye and head movement to capture the ‘out there’.

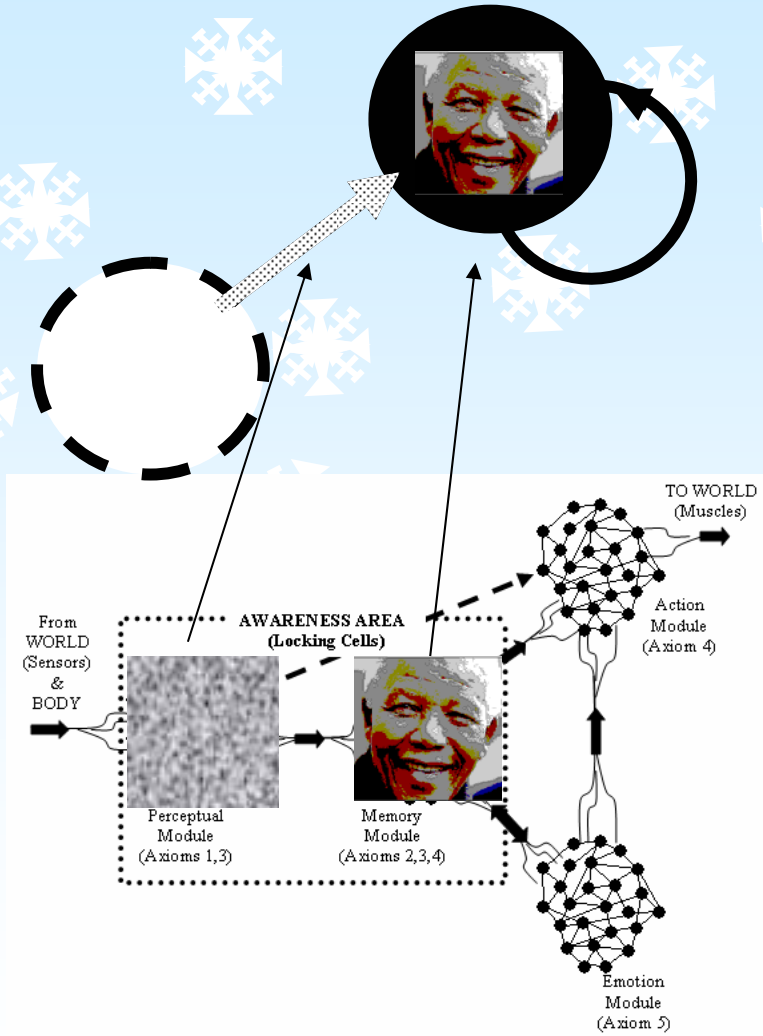

TO WORLD
(Muscles)
From
WORLD
(Sensors)
&
BODY
AWARENESS AREA
(Locking Cells)
Action
Module
(Axiom 4)
Ax1
Perceptual
Module
(Axioms 1,3)
Memory
Module
(Axioms 2,3,4)
Emotion
Module
(Axiom 5)

2. Imagination: Recursive cellular structures that store accessible knowledge as state structure.

(2004): A 'kernel architecture' capable of supporting the five axioms:



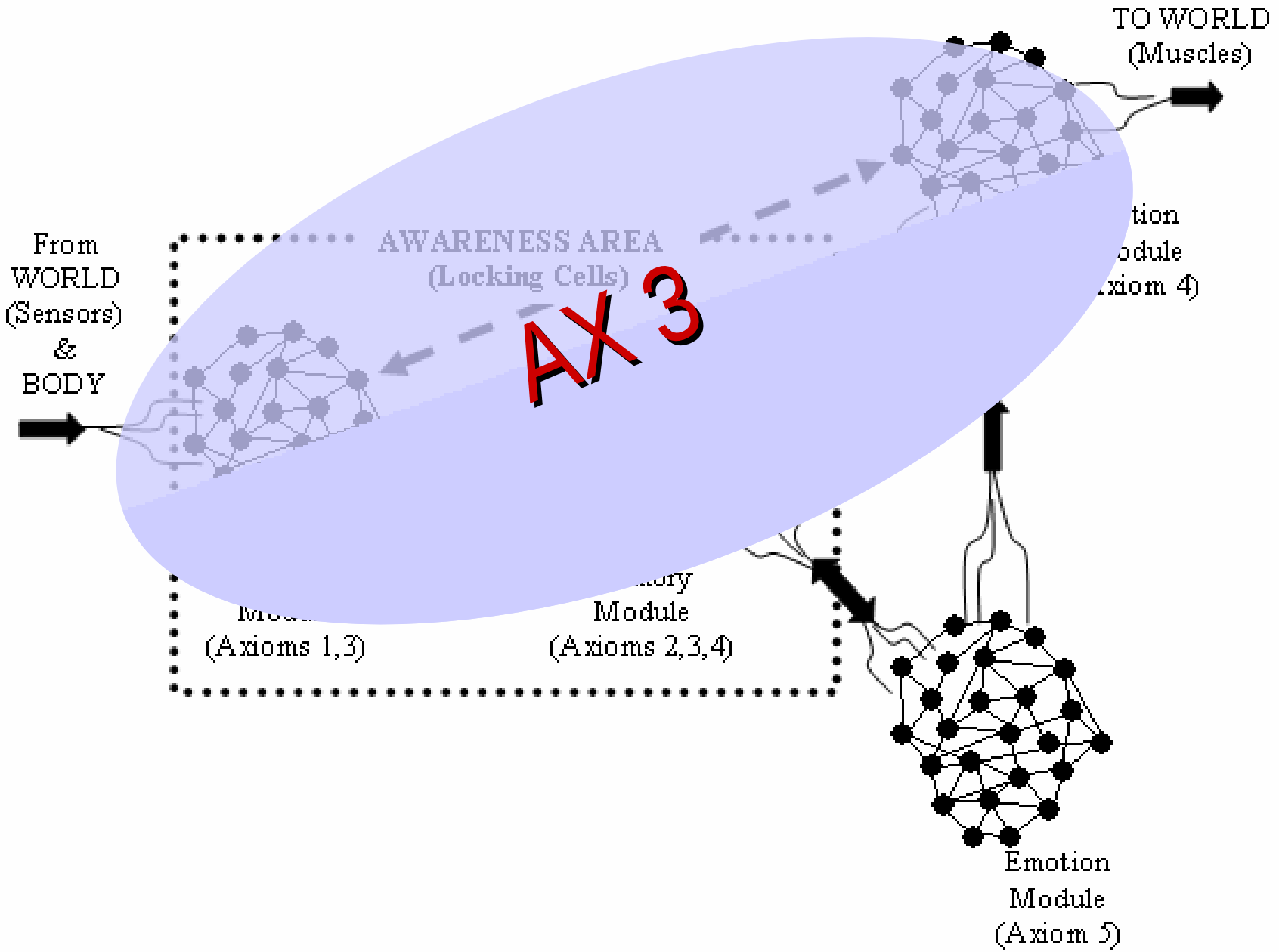
The build-up of experience in the imagination module

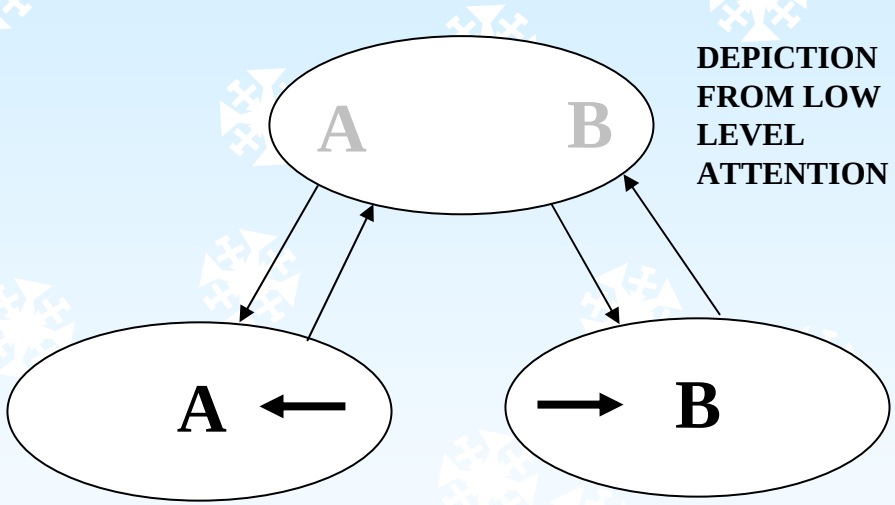


A Movie

3. Attention: Evolved muscle-driving mechanisms driven from sensory data *and* higher level (1 and 2) machinery optimised on accuracy of depiction.

(2004): A 'kernel architecture' capable of supporting the five axioms:



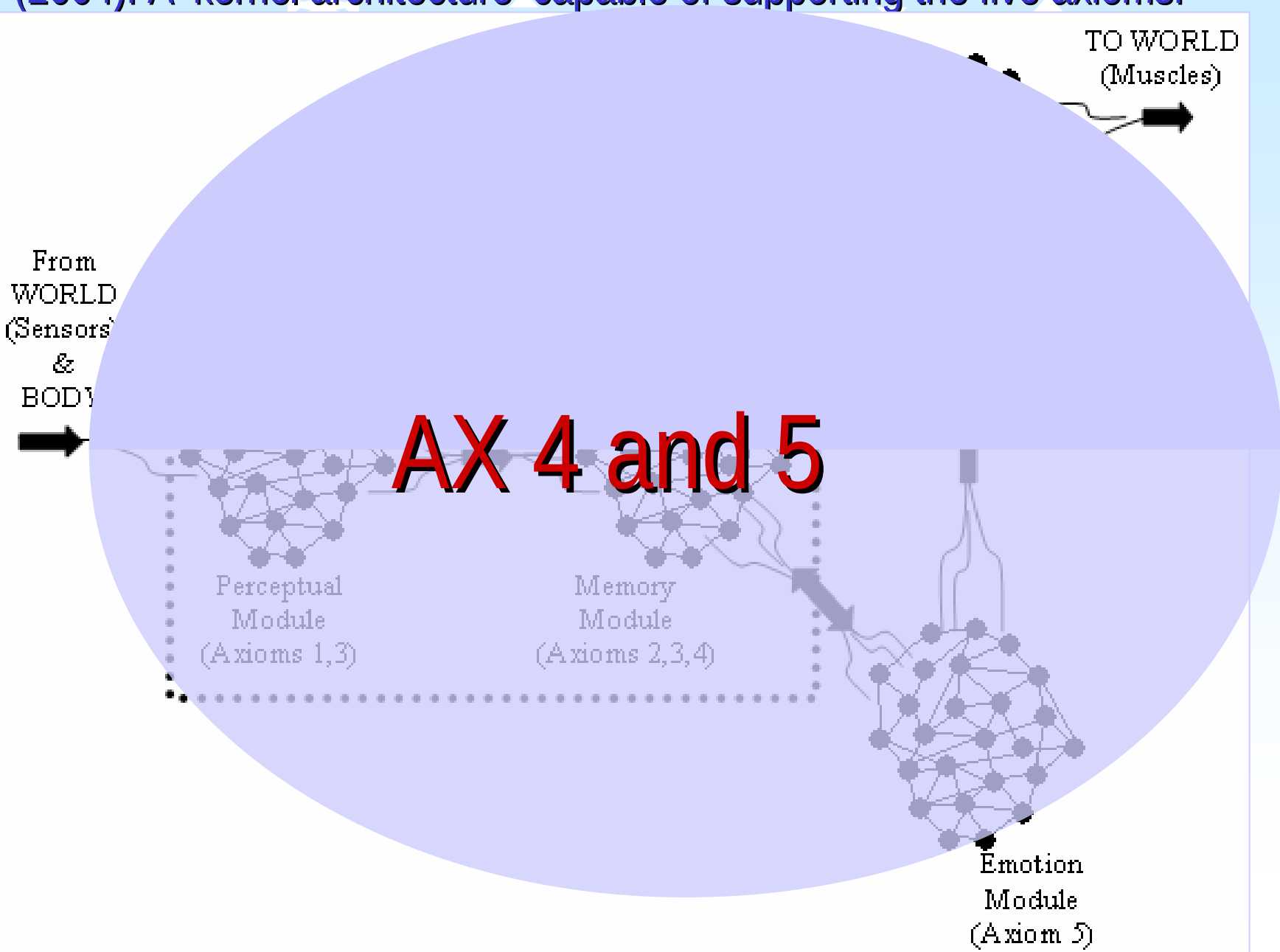


ATTENTIONAL STATES DUE TO (SAY) HEAD MOVEMENT

ALSO TRANSFERS ICONICALLY TO IMAGINATION MODULE

Volition and Emotion: Non-deterministic transitions of state spaces in 2 machinery are evaluated in the emotion module until sufficient 'wantedness' is built up to trigger an action.

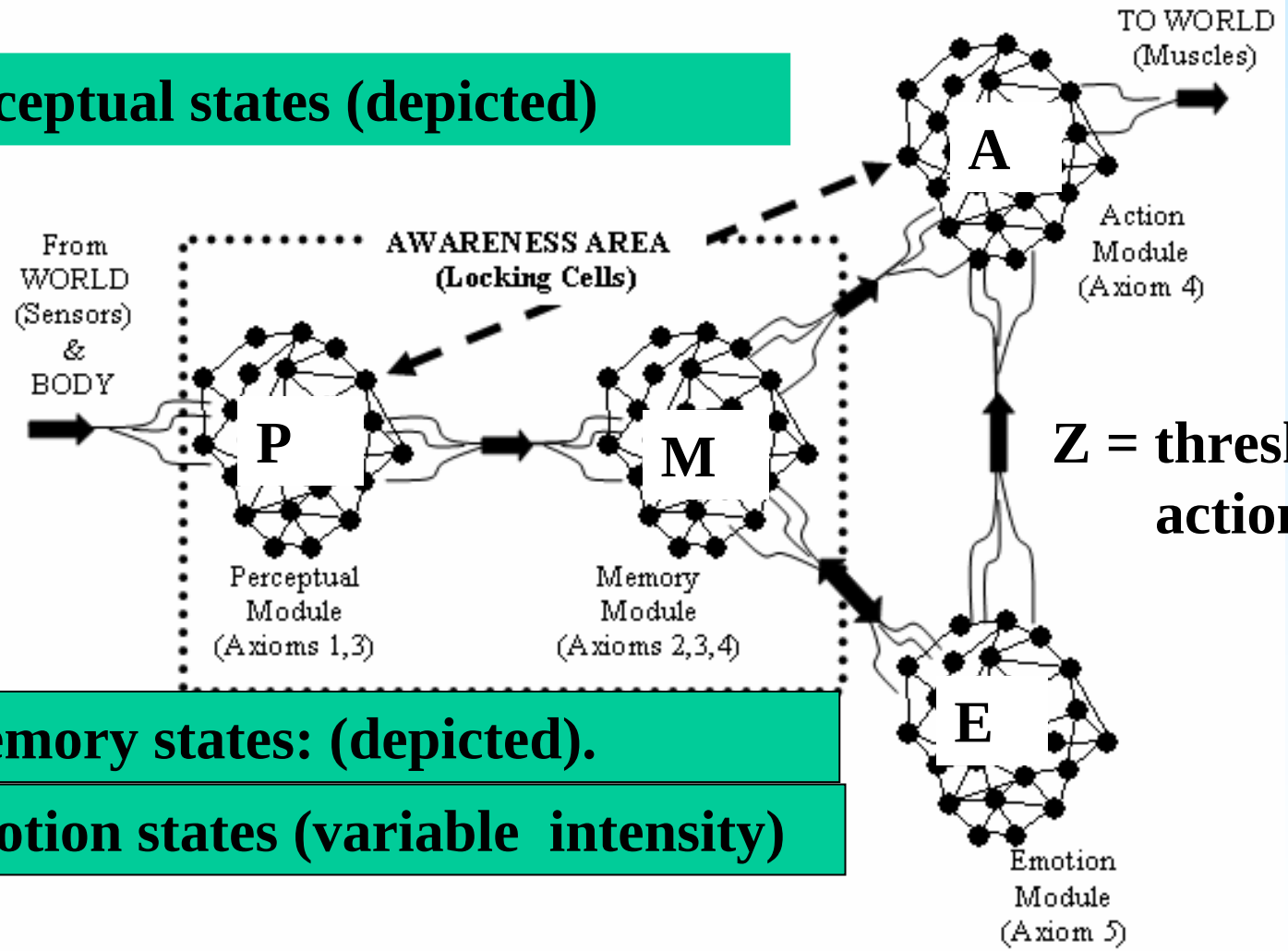
(2004): A 'kernel architecture' capable of supporting the five axioms:



THE 'KERNEL' ARCHITECTURE

An interplay of neural state machines.

P = Perceptual states (depicted)



Z = thresholded action index

M = Memory states: (depicted).

E = Emotion states (variable intensity)

A = Decided Action States (causing muscular activity)

THE PIZZA HOUSE

p_1 : looking at the menu

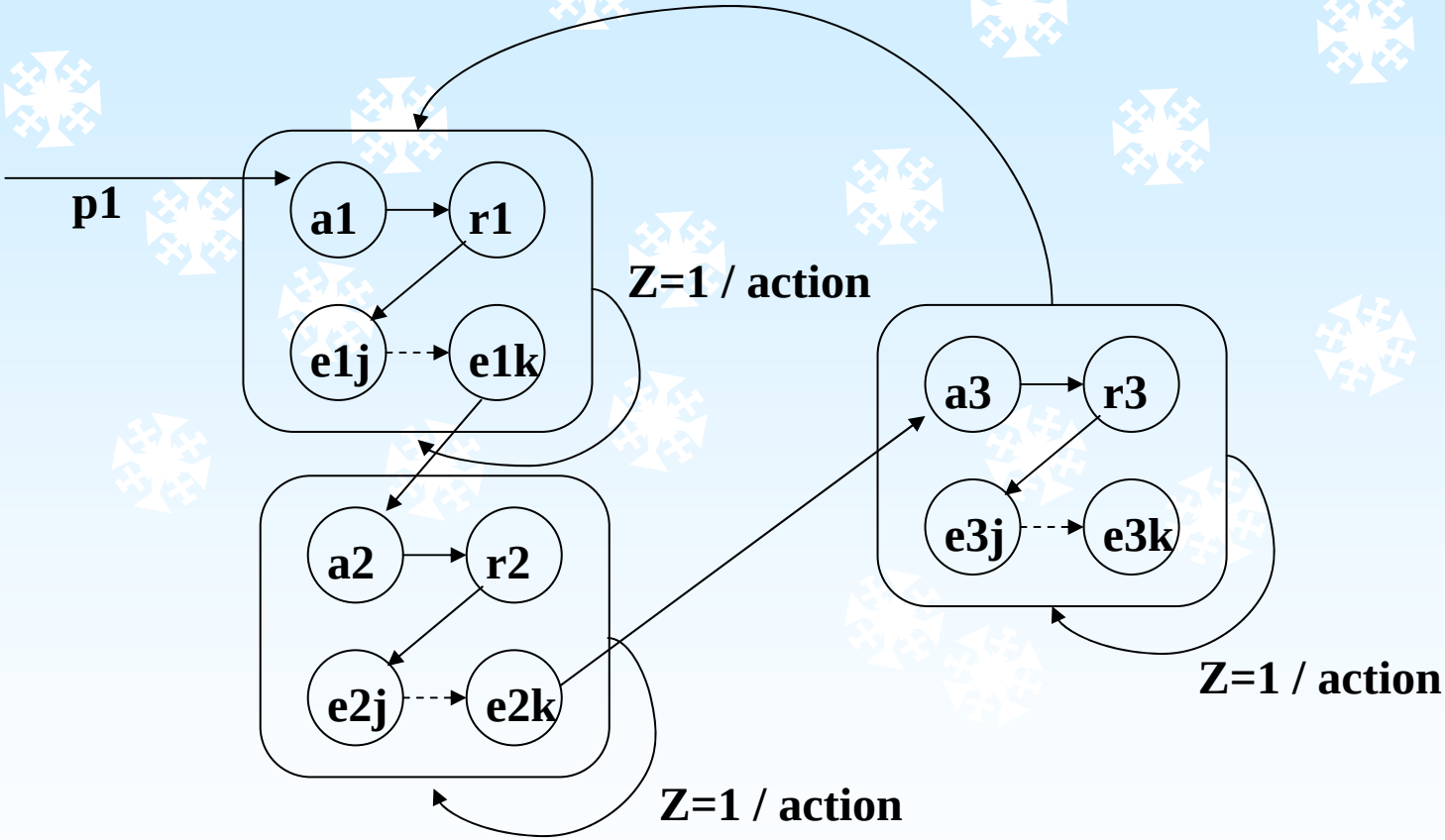
a_1, a_2, a_3: recognise choices pizza, pasta or salad.

r_1,r_2, r_2: memory of properties of each dish

e_1,e_2, e_3: memory of pleasure, guilt, satiation for each rx.

$W = e_1(i) + e_2(i) + e_3(i) + rand$, evaluation of intensity for each r towards generating Z

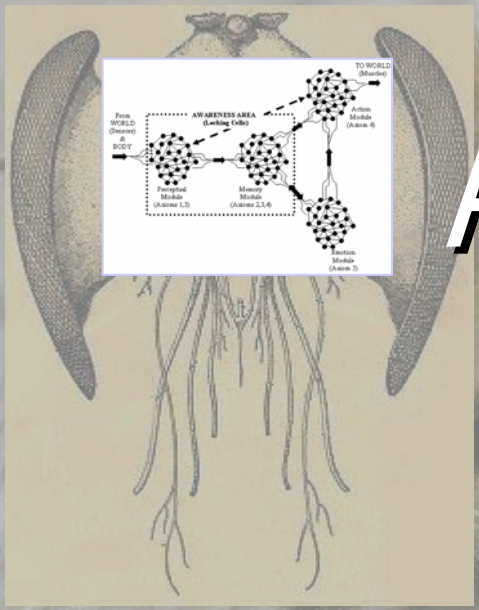
THE STATE STRUCTURE OF THINKING AND WANTING



A virtual machine for studying visual consciousness

ARE BEES CONSCIOUS?

YES THEY HAVE A DEPICTIVE ARCHITECTURE IN THEIR BRAINS

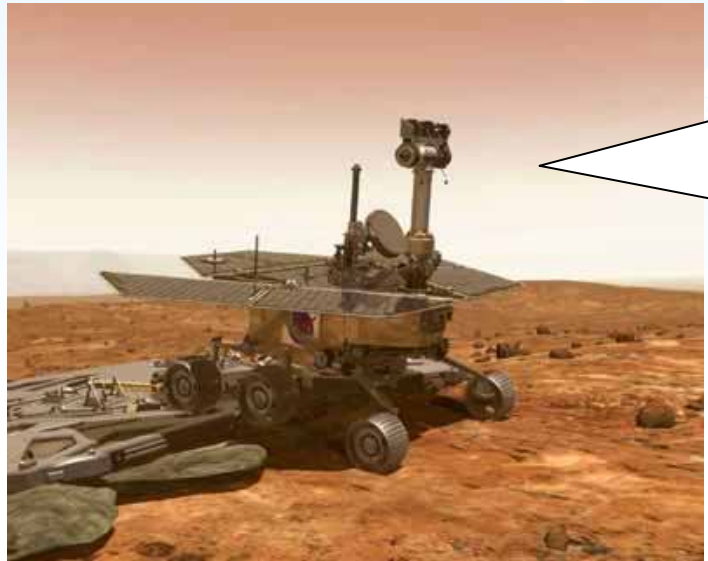


Can the constructive approach help answer important questions?

What is the difference between conscious people, animals and machines?

CONTENT: What the organism DOES with its depictive architecture!

COGITO



Is the terrain safe for me?
Are my batteries fully charged?

CONTENT: What the organism DOES with its depictive architecture!

COGITO

In other words:
Mechanisms for consciousness are similar

but
MINDS
are very different

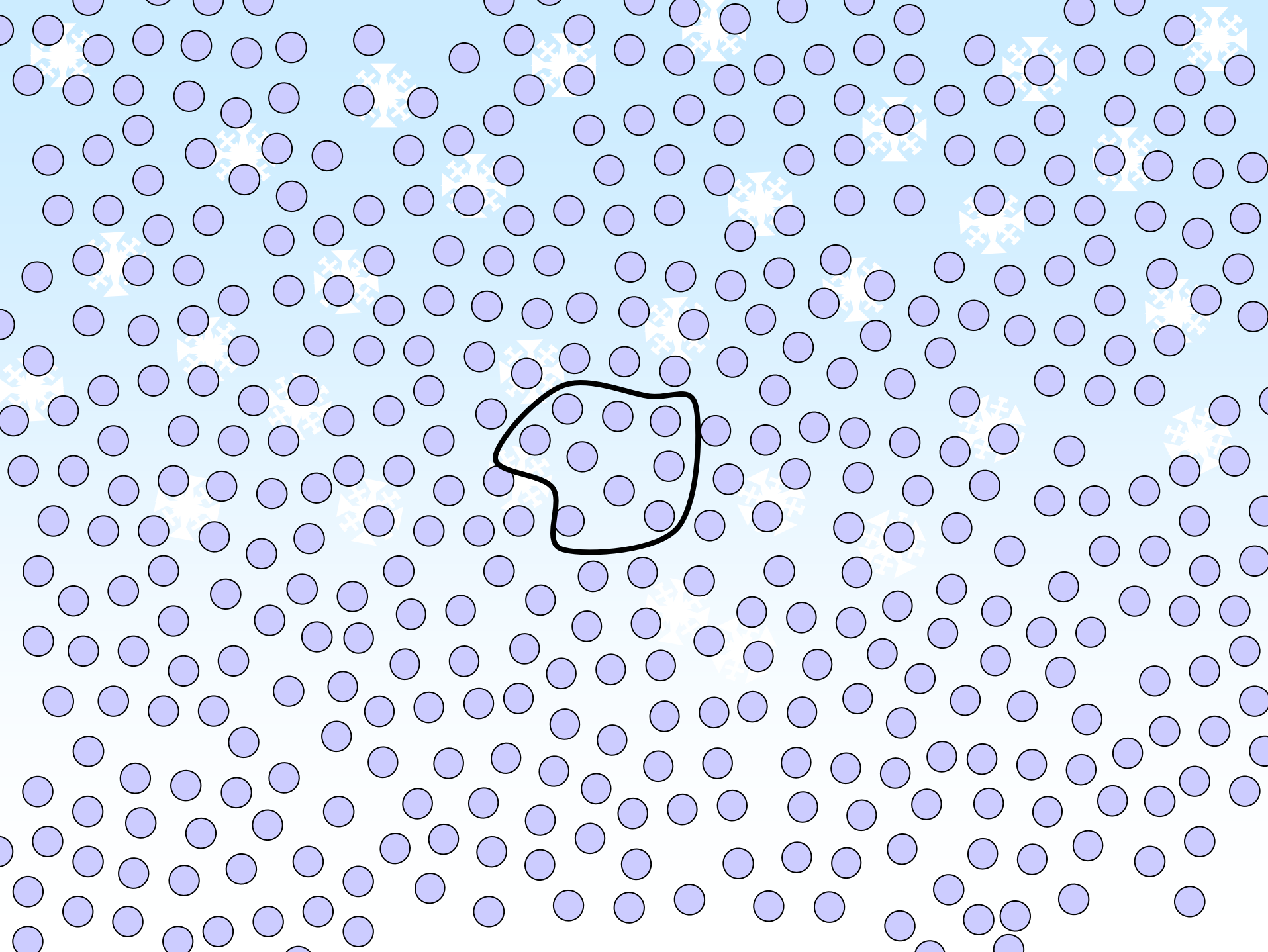
safe

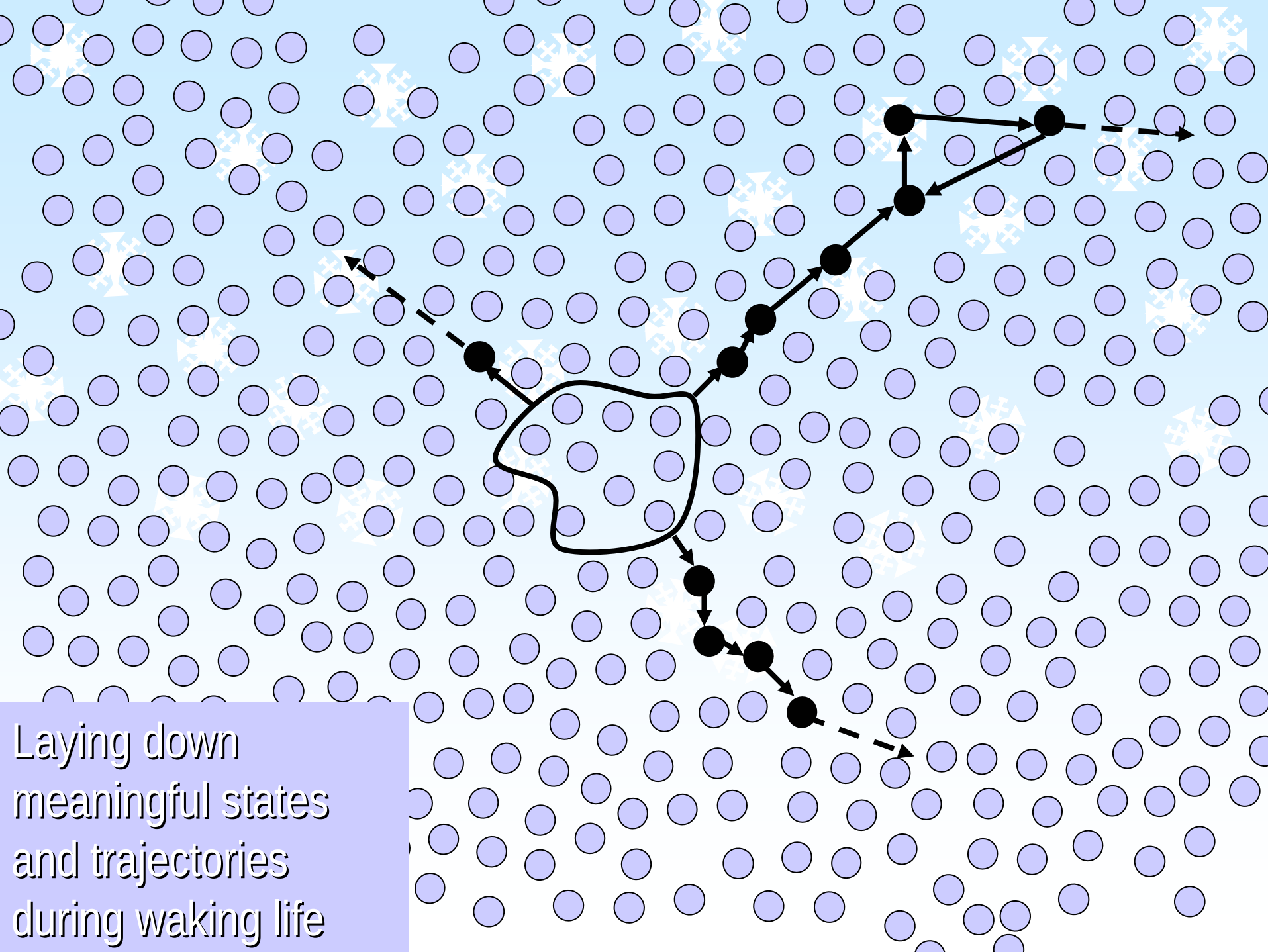
eries

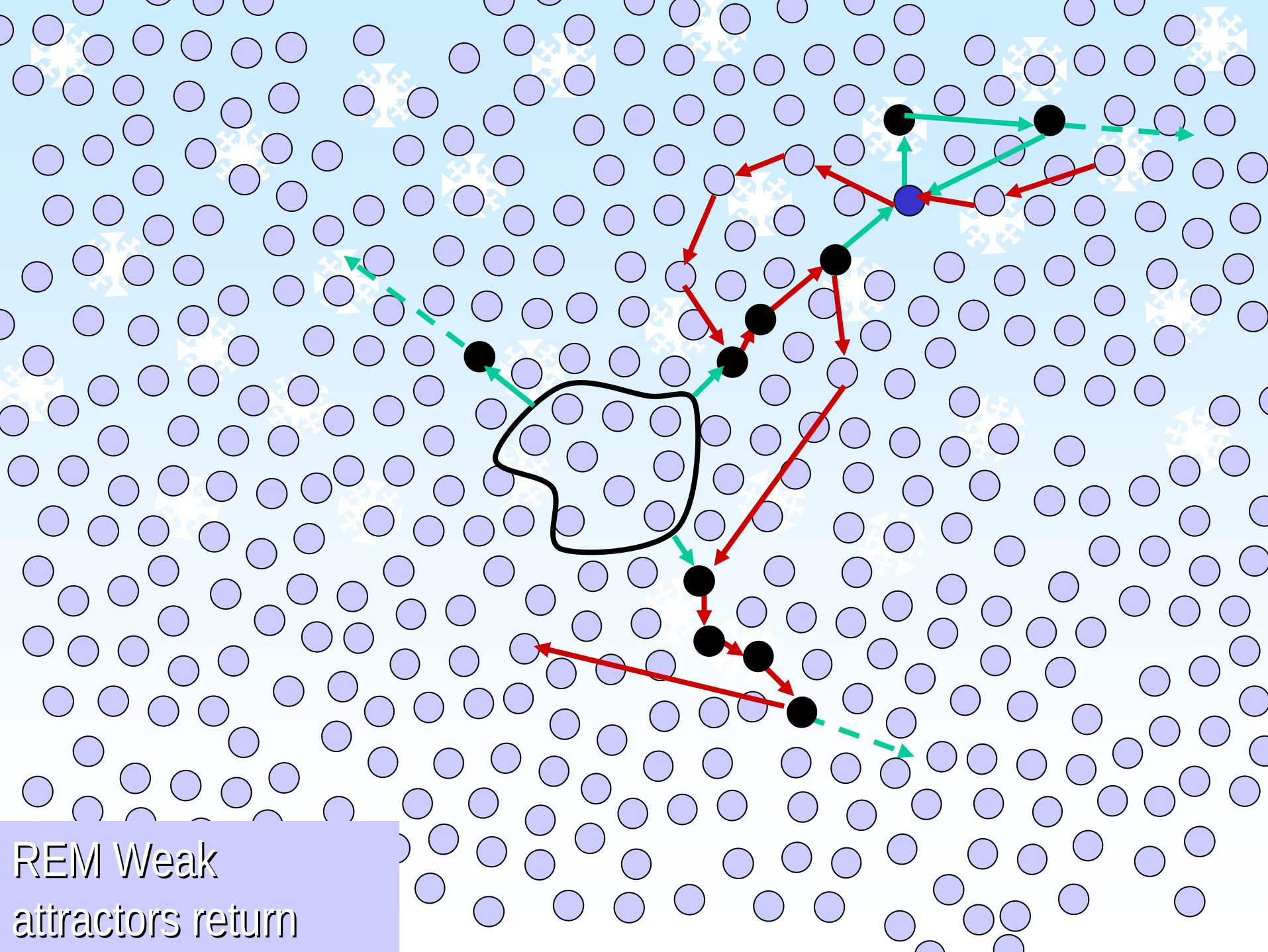
ed?

Can the constructive approach help answer important questions?

What are dreams?

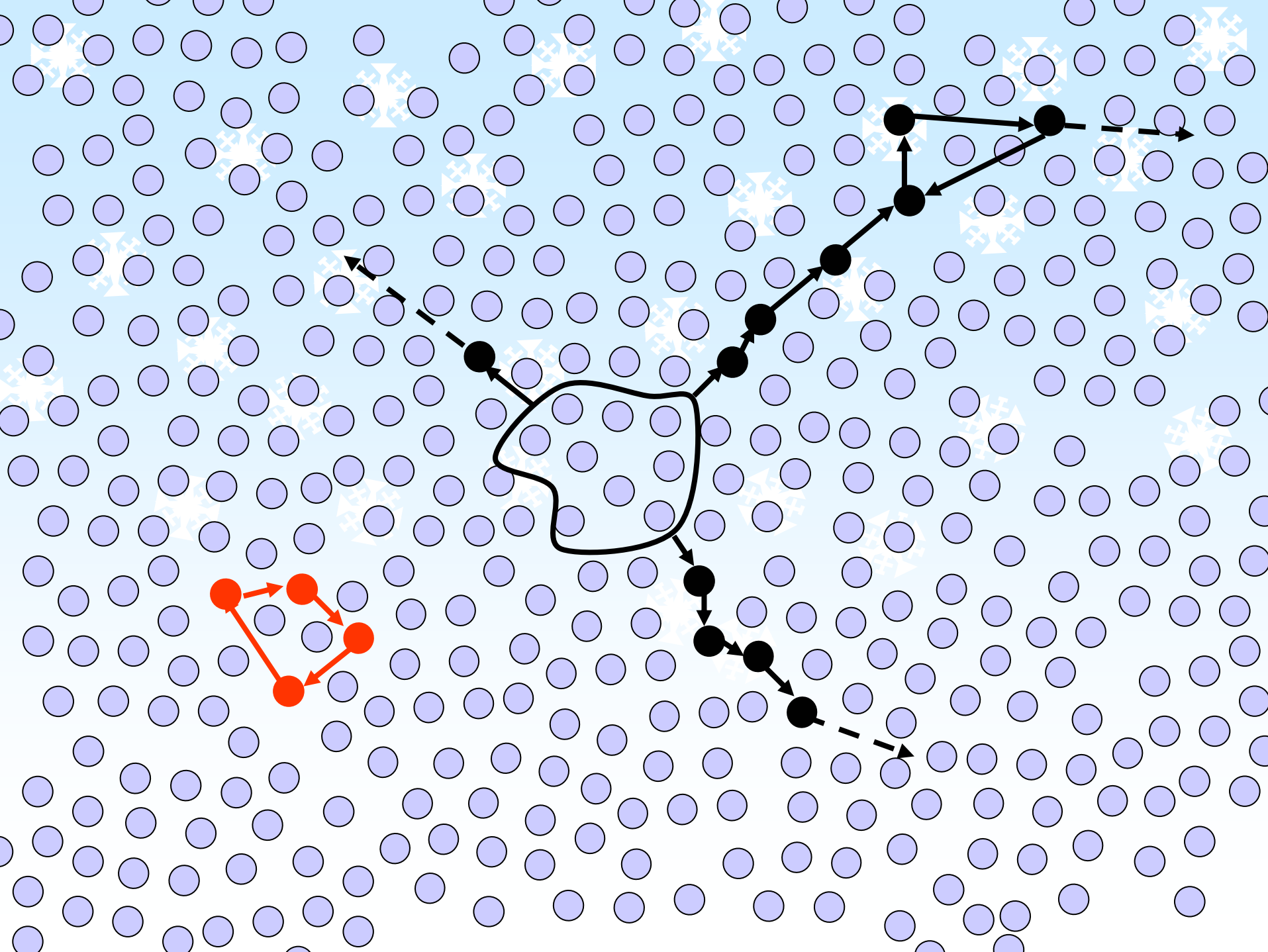



Laying down
meaningful states
and trajectories
during waking life


REM Weak
attractors return

Can the constructive approach help answer important questions?

What is ‘the unconscious’?



Can the constructive approach help answer important questions?

What is meant by free will?

What is the Soul?

Can we understand mental deficits better?

To Finish

We have learned that consciousness can be studied on machines to understand it better.

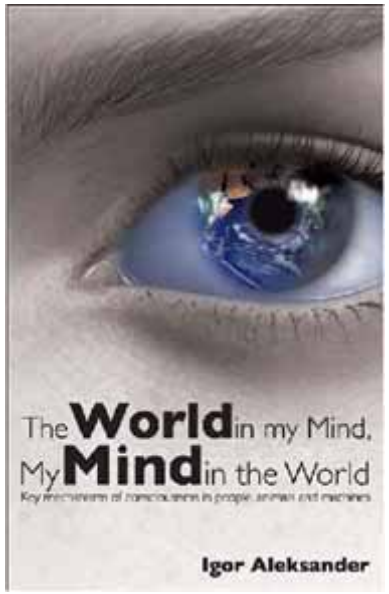
This is useful in suggesting what our brains do to make us enjoy Christmas.

Have a Happy one!!!

Feel free to ask: i.aleksander@imperial.ac.uk

References

General Reading



For the Specialist

Aleksander & Dunmall: An extension to the hypothesis of the asynchrony of visual consciousness' *Proc Royal Soc. London, B*, 267, Number 1439, January 22, 2000

Aleksander & Dunmall: Axioms and Tests for the Presence of Minimal Consciousness in Agents. *Jour. Of Consciousness Studies*¸10, 4-5, 7-19, 2003.