Determined

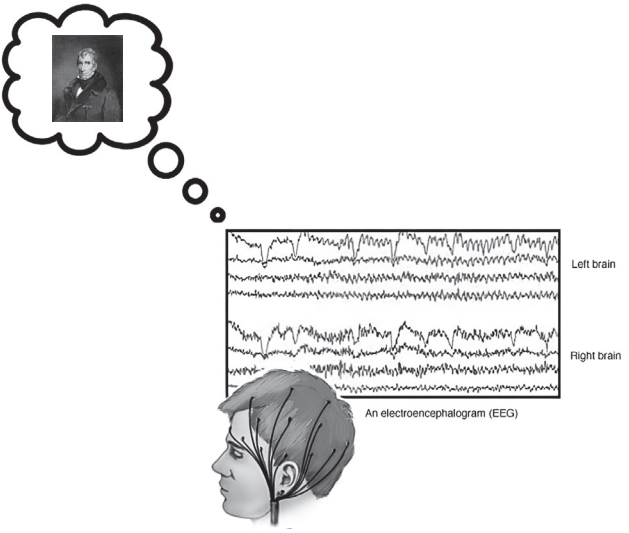
A Science of Life without Free Will

Robert M. Sapolsky

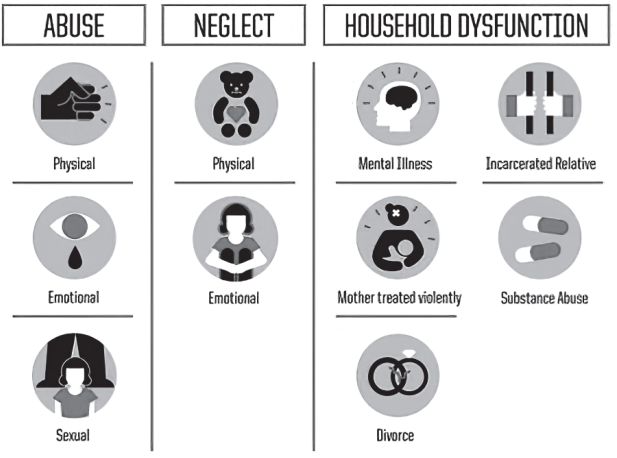
SUPPLEMENTAL RESOURCES

-

EEG DIAGRAM

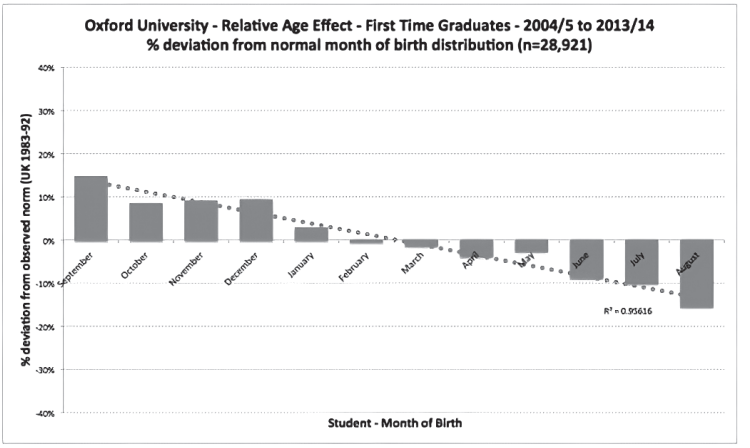


ACE TABLE



Source: Centers for Disease Control and Prevention

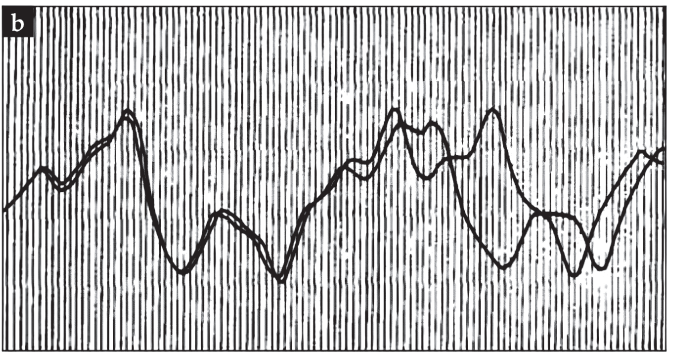
RELATIVE AGE EFFECT CHART



WHAT YOU WERE GIVEN TABLE

"Biological stuff"	*Do you have grit?*
Having destructive sexual urges	*Do you resist acting upon them?*
Being a natural marathoner	*Do you fight through the pain?*
Not being all that bright	*Do you triumph by studying extra hard?*
Having a proclivity toward alcoholism	*Do you order ginger ale instead?*
Having a beautiful face	*Do you resist concluding that you're entitled to people being nice to you because of it?*

PRE- AND POSTLUNCH TRACINGS SUPERIMPOSED CHART



TIME

CHAOS THEORY TALK DOCUMENT

AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE, 139th MEETING

Subject.....Predictability; Does the Flap of a Butterfly's wings in Brazil Set Off a Tornado in Texas?

Author.....Edward N. Lorenz, Sc.D.
Professor of Meteorology

Address.....Massachusetts Institute of Technology
Cambridge, Mass. 02139

Time.....10:00 a.m., December 29, 1972

Place.....Sheraton Park Hotel, Wilmington Room

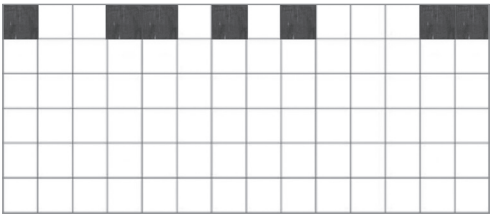
Program.....AAAS Section on Environmental Sciences
New Approaches to Global Weather: GARP
(The Global Atmospheric Research Program)

Convention Address.....Sheraton Park Hotel

RELEASE TIME
10:00 a.m., December 29

4

CHAOTICISM AND SENSITIVE DEPENDENCE EXERCISE



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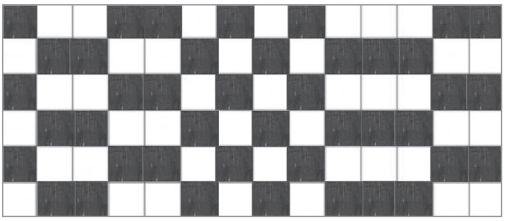


As the main point, starting with either of these rules, if you know the starting state (i.e., the pattern in row 1), you can accurately predict what a row anywhere in the future will look like. Our linear universe again.

Let's go back to our row 1:

Now whether a particular row 2 box will be open or filled is determined by the state of three boxes—the row 1 box immediately above and the row 1 box's neighbor on each side.

Here's a random rule for how the state of a trio of adjacent row 1 boxes determines what happens in the row 2 box below: *A row 2 box is filled if*

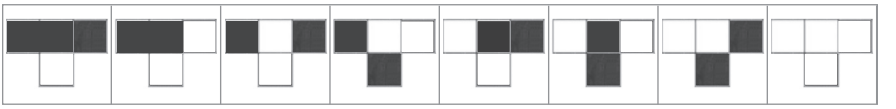
and only if one of the trio of boxes above it is filled in. Otherwise, the row 2 box will remain open.

Let's start with the second box from the left in row 2. Here is the row 1 trio immediately above it (i.e., the first three boxes of row 1):

One of three boxes is filled, meaning that the row 2 box we're considering will get filled:

Look at the next trio in row 1 (i.e., boxes 2, 3, and 4). Only one box is filled, so box 3 in row 2 will also be filled:

In the row 1 trio of boxes 3, 4, and 5, two boxes (4 and 5) are filled, so the next row 2 box is left open. And so on. The rule we are working with—if and only if one box of the trio is filled, fill in the row 2 box in question—can be summarized like this:

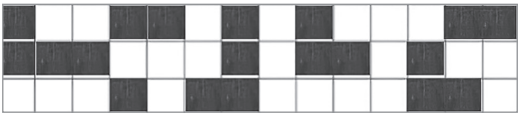


There are eight possible trios (two possible states for the first box of a trio times two possible for the second box times two for the third), and only trios 4, 6, and 7 result in the row 2 box in question being filled.

Back to our starting state, and using this rule, the first two rows will look like this:

But wait—what about the first and last boxes of row 2, where the box above has only one neighbor? We wouldn't have that problem if row 1 were infinitely long in both directions, but we don't have that luxury. What do we do with each of them? Just look at the box above it and the single neighbor, and use the same rule—if one of those two is filled, fill in the row 2 box; if both or neither of the two is filled, row 2 box is open. Thus, with that addendum in place, the first 2 rows look like this:

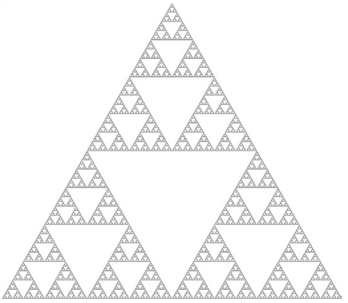
Now use the same rule to generate row 3:



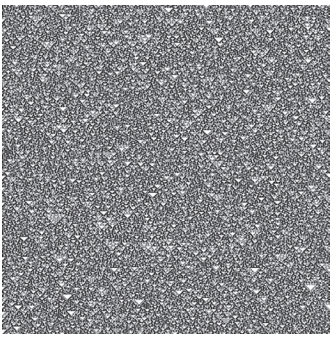
Keep going, if you have nothing else to do.
Now let's use this starting state with the same rule:

The first 2 rows will look like this:

Complete the first 250 or so rows and you get this:



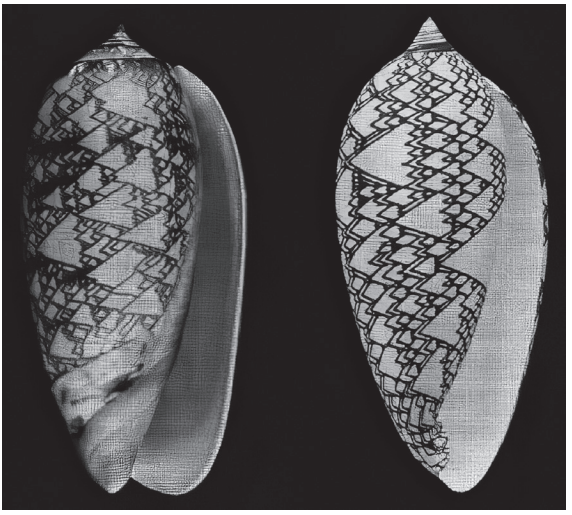
Take a different, wider random starting state, apply the same rule over and over, and you get this:



Whoa.

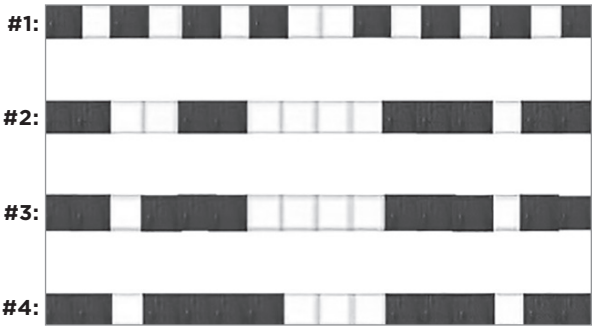
Now try this starting state:

By row 2, you get this:



An actual shell on the left, a computer-generated pattern on the right

RULE 22 EXERCISE

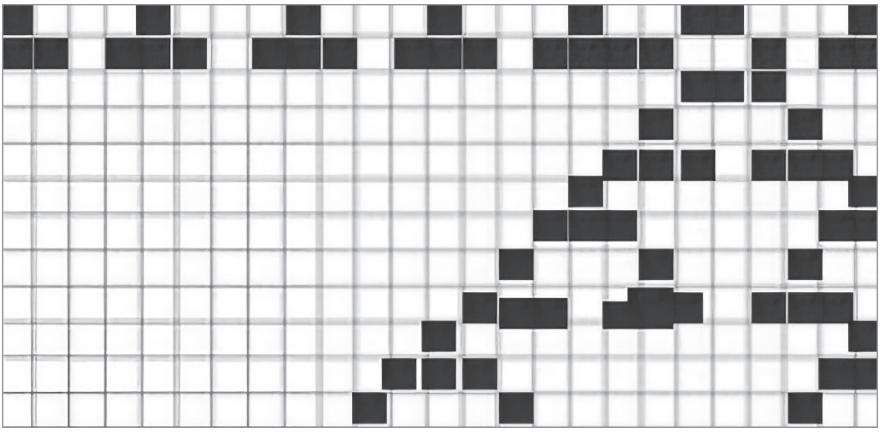


if it could have arisen from multiple different starting states, another defining feature of the chaoticism of this system.

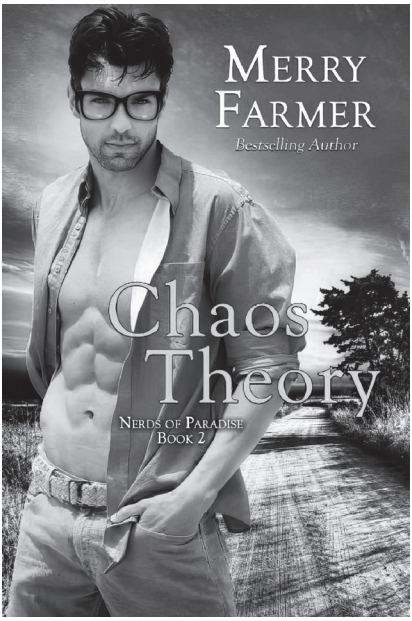
Finally, consider the following starting state:

Which goes extinct by row 3:

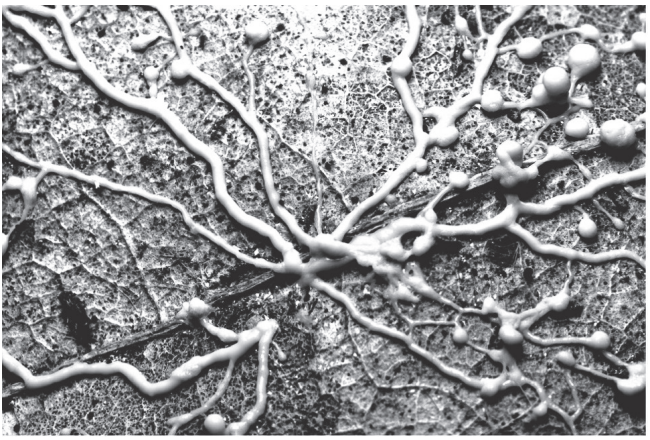
Introduce a smidgen of a difference in this nonviable starting state, namely that the open/filled status of just one of the twenty-five boxes differs—box 20 is filled instead of open:



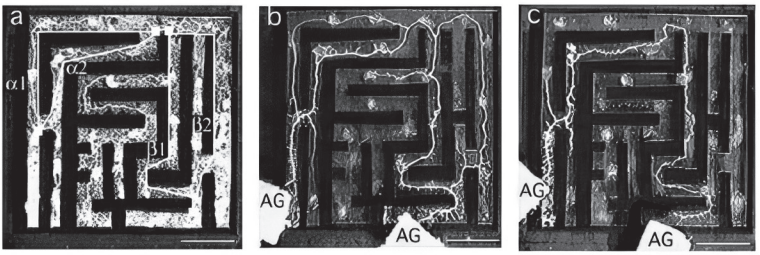
PICTURE


MERRY
FARMER
Bestselling Author
Chaos
Theory
NERDS OF PARADISE
BOOK 2

MOLD PATHWAYS FIGURE

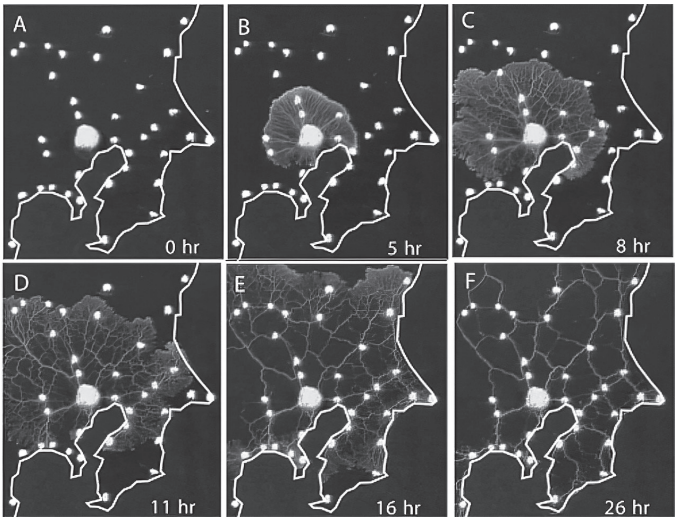


MOLD PATHWAYS DIAGRAM



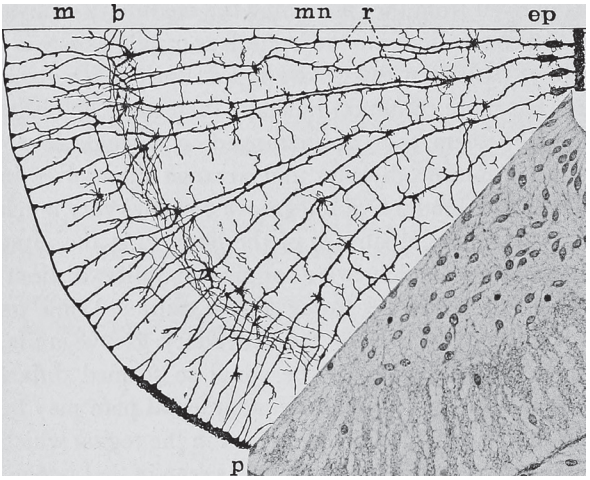
Initially, the slime mold fills every path (panel a); it then begins retracting from superfluous paths (panel b), until eventually reaching the optimal solution (panel c). (Ignore the various markings.)

TOKYO TRAVELING SLIME MOLD DIAGRAM



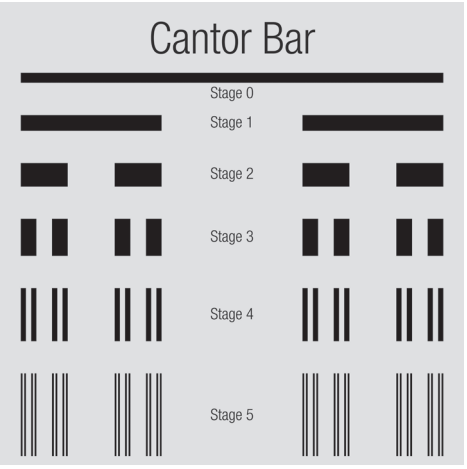
TYPES OF NEURONS IN CORTEX LAYERS FIGURE

RADIAL GLIA FIGURE

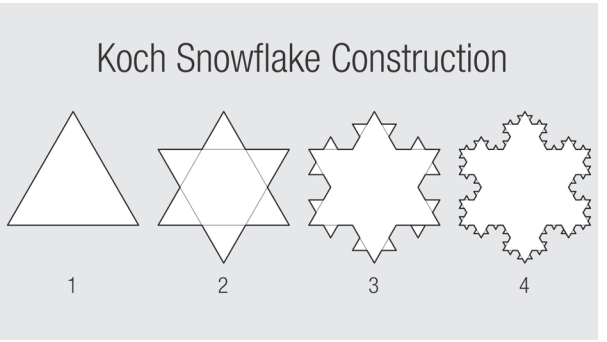


Radial glia radiating outward from the center of a cross section

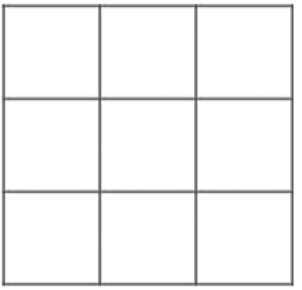
CANTON BAR FIGURE



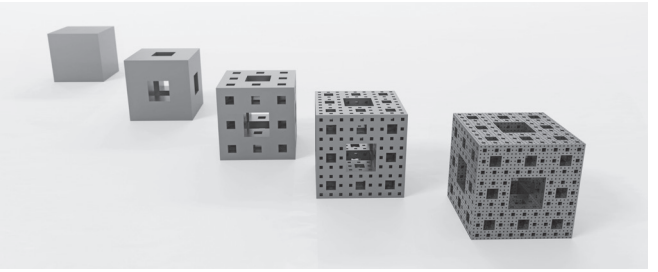
KOCH SNOWFLAKE CONSTRUCTION DIAGRAM



Now three dimensions. Take a cube. Each of its faces can be thought of as being a three-by-three grid of nine boxes. Take out the middle-most of those nine boxes, leaving eight:



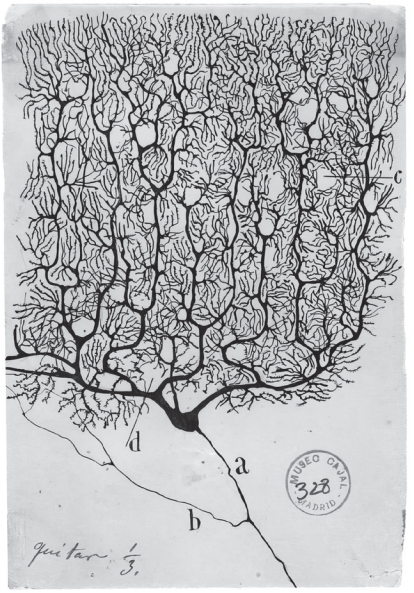
MENGER SPONGE ILLUSTRATION



BRANCHING PATTERNS IN CAPILLARY BEDS FIGURE

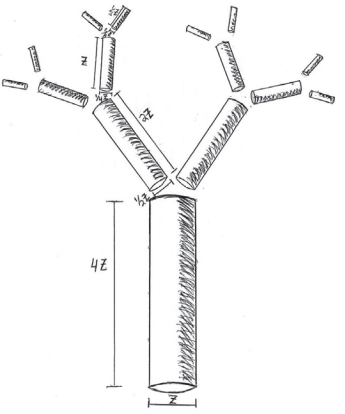
Branching patterns in capillary beds

TEXTBOX DRAWING OF A NEURON

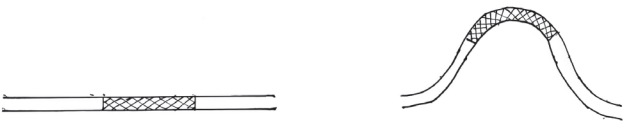


A classic textbook drawing of an actual neuron

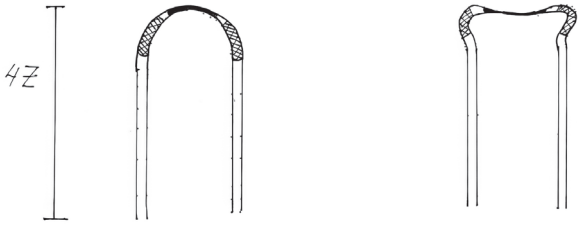
TUBE GROWING FIGURE



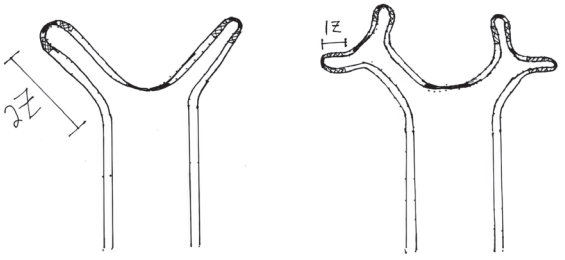
NEURON GROWING FIGURE 1



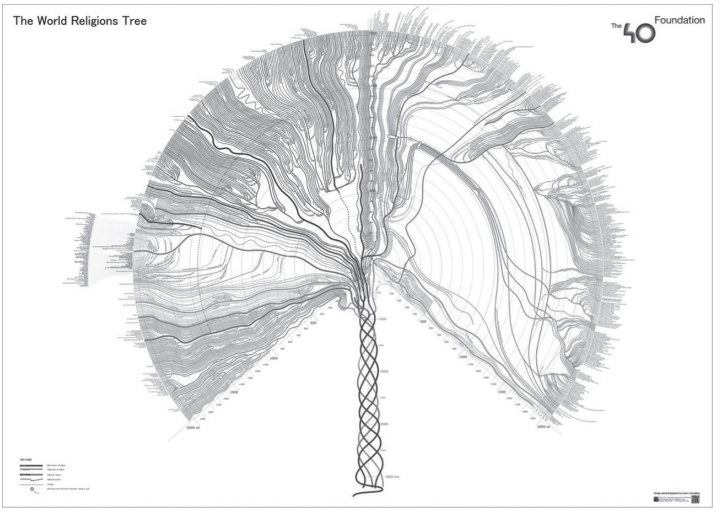
NEURON GROWING FIGURE 2



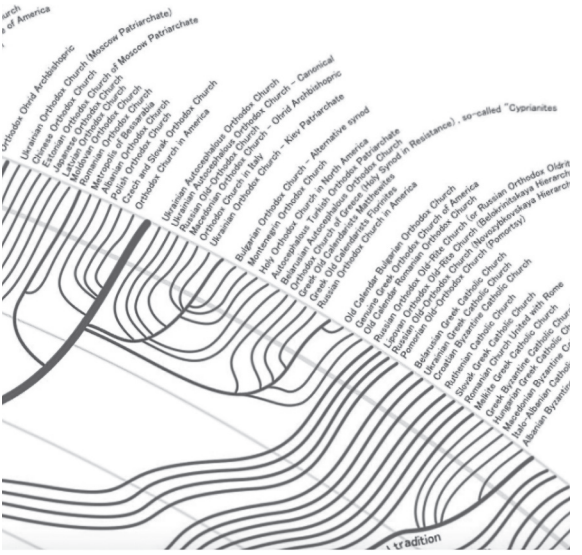
NEURON GROWING FIGURE 3



WORLD RELIGIONS TREE

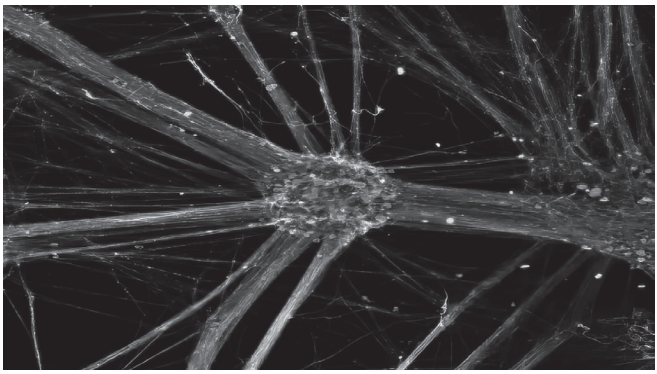


HISTORY OF RELIGIOUS BRANCHING (PIECE)

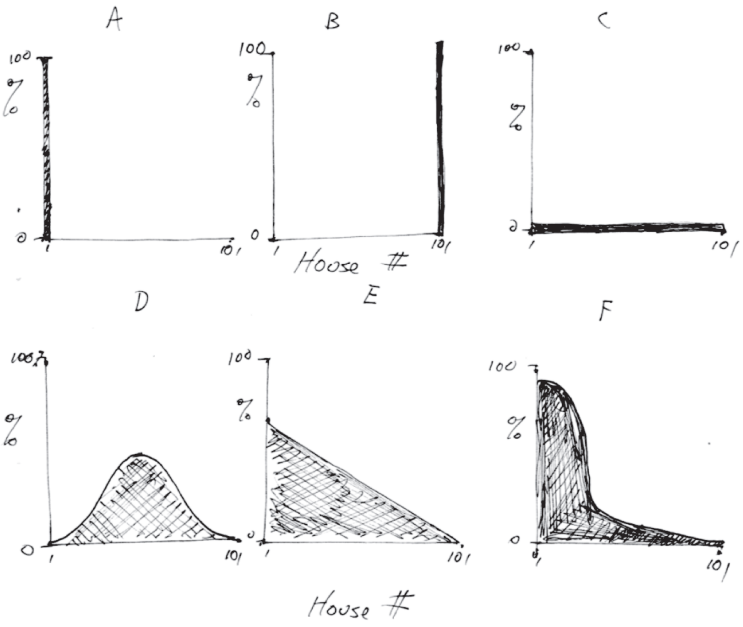


One tiny piece of the history of religious branching

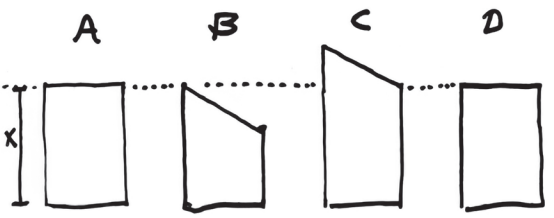
NEURONS GROWING FIGURE



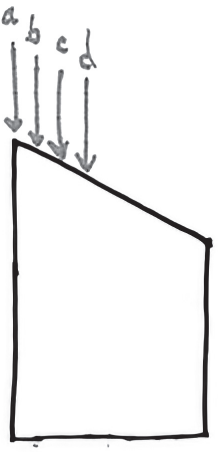
80:20 RULE DIAGRAMS



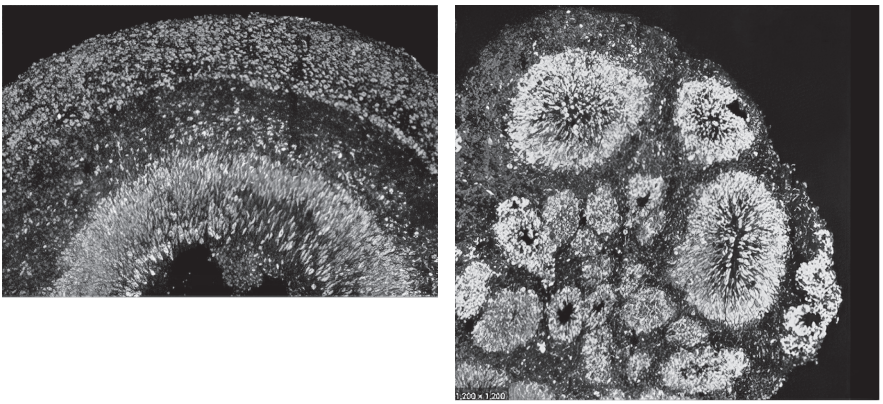
EXAMPLE OF EMERGENCE 1



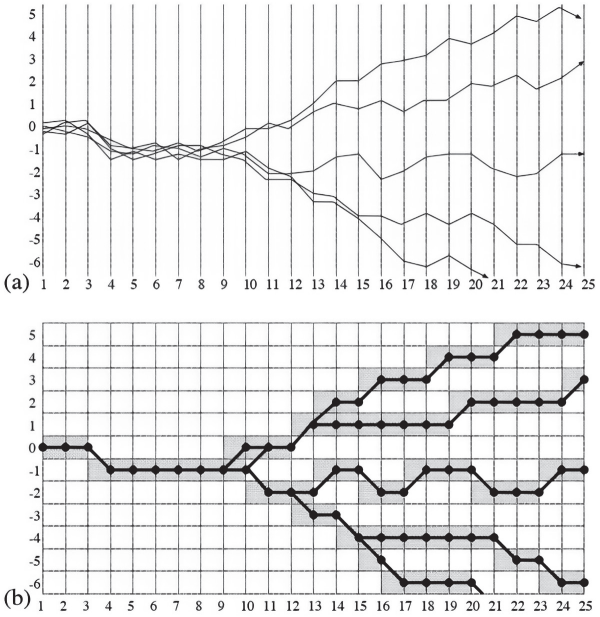
EXAMPLE OF EMERGENCE 2



ORGANOID NEURONS FIGURE

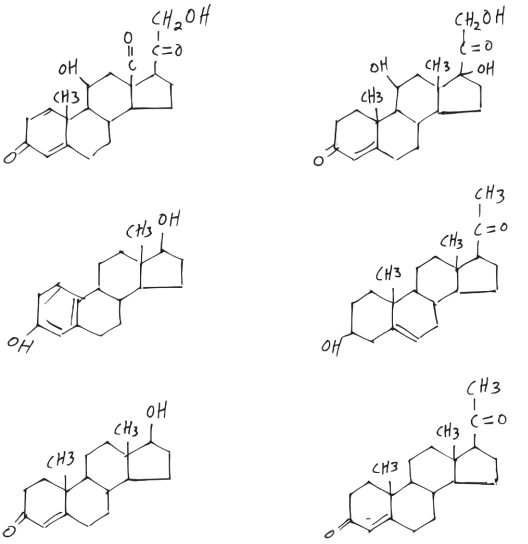


EMERGENT INDETERMINISM DIAGRAM 1

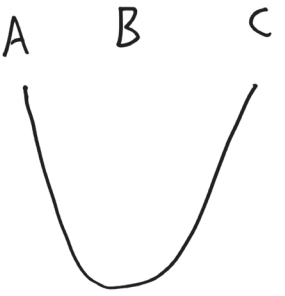


Emergent indeterminism

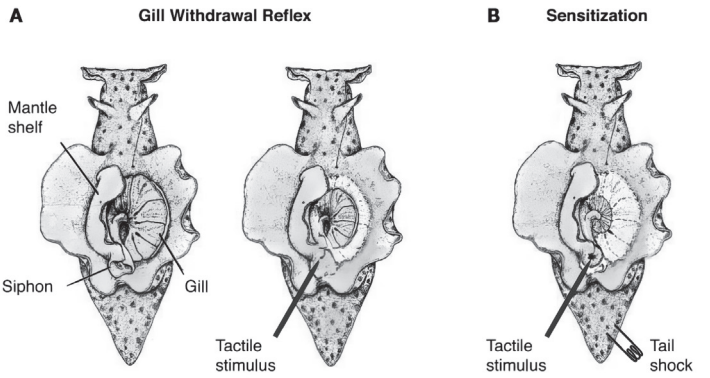
EMERGENT INDETERMINISM DIAGRAM 2



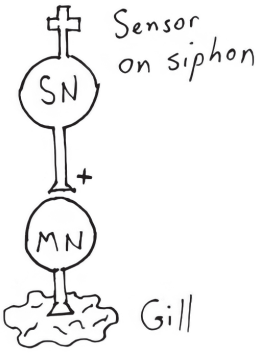
FREE WILL CURVE



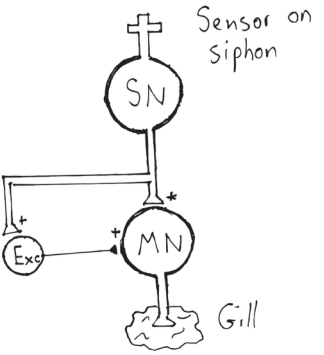
APLYSIA CALIFORNICA FIGURE



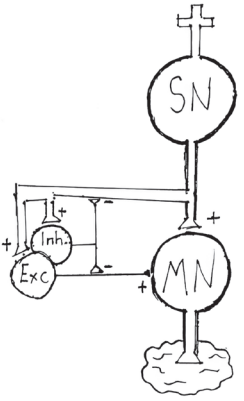
APLYSIA SN-MN CONNECTION DIAGRAM



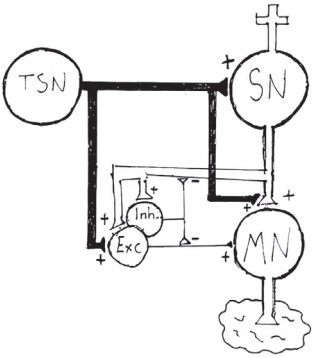
APLYSIA SN_EXC_MN ROUTE DIAGRAM



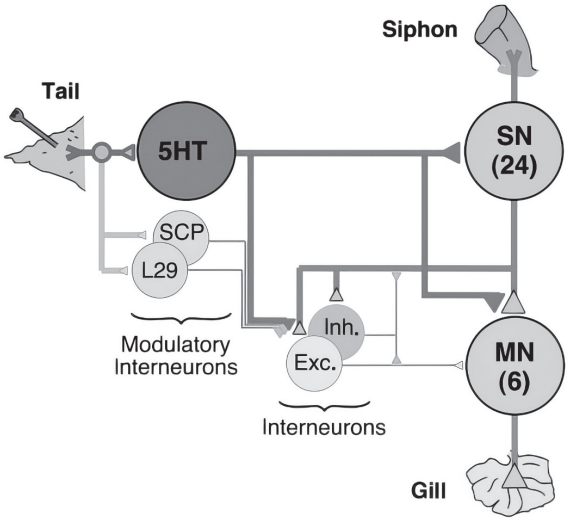
APLYSIA SN/ MN/ EXC/ INH CIRCUITRY DIAGRAM



APLYSIA TSN DIAGRAM

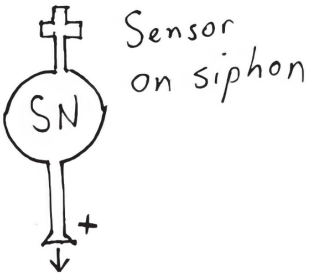


ERIC KANDEL'S APLYSIA FIGURE 1

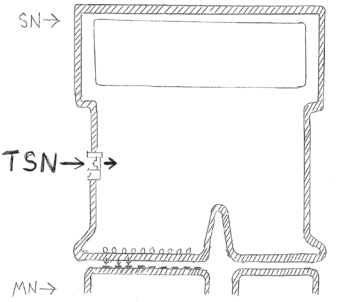


Some minor details: 5HT is the chemical abbreviation for the neurotransmitter (serotonin) used by the TSN. SCP and L29 fine-tune the system; we've ignored them, for simplicity. There are 24 SNs in a siphon, converging on to 6 MNs.

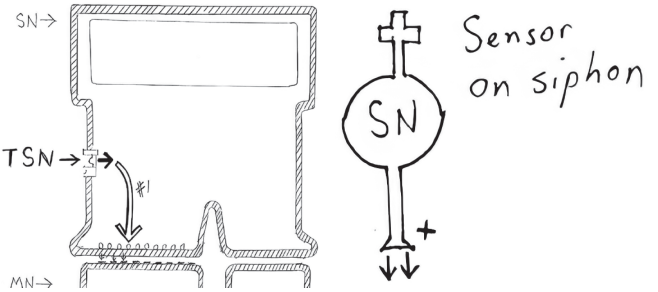
APLYSIA'S GILL MECHANISM DIAGRAM 1



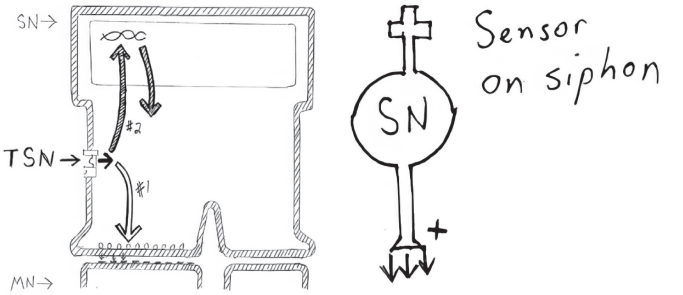
APLYSIA'S GILL MECHANISM DIAGRAM 2



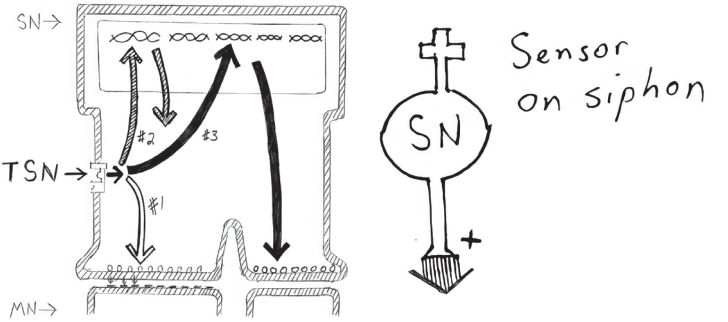
APLYSIA'S GILL MECHANISM DIAGRAM 3



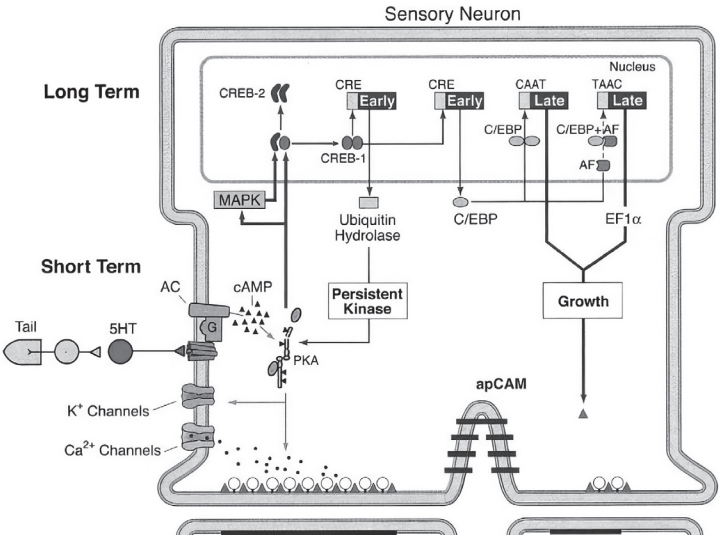
APLYSIA'S GILL MECHANISM DIAGRAM 4



APLYSIA'S GILL MECHANISM DIAGRAM 5



ERIC KANDEL'S APLYSIA FIGURE 2

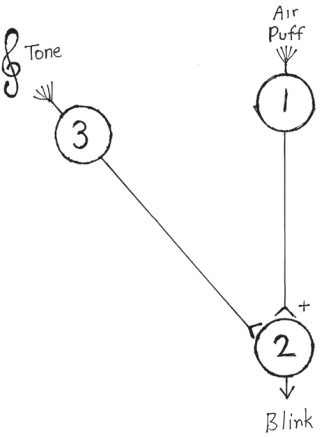


APLYSIA CALIFORNICA PICTURE

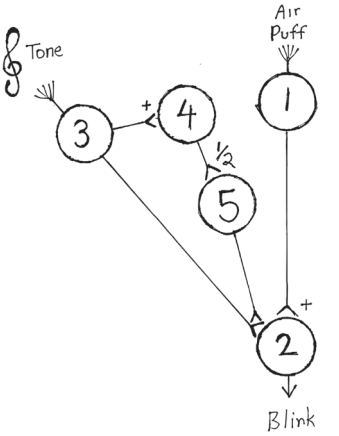
Aplysia californica. *As should be obvious, the one on the left is happy, in an unreflective kind of way. The one on the right is a wonderful* Aplysia *stuffie that could be your child's comfort object all the way until their freshman year of college.*

BLINKING EXAMPLE DIAGRAM 1

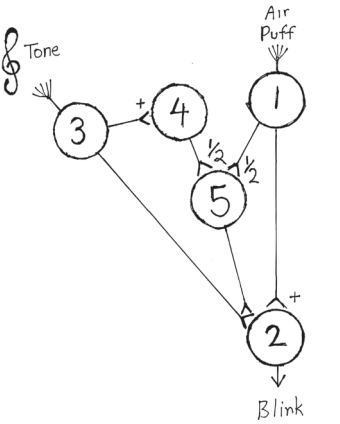
BLINKING EXAMPLE DIAGRAM 2



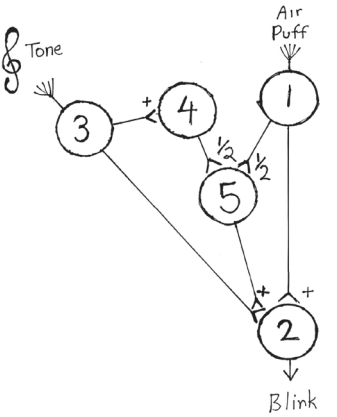
BLINKING EXAMPLE DIAGRAM 3



BLINKING EXAMPLE DIAGRAM 4



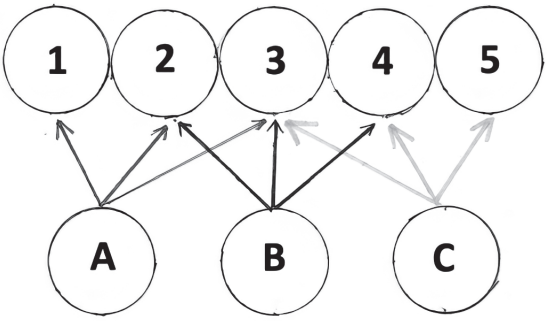
BLINKING EXAMPLE DIAGRAM 5



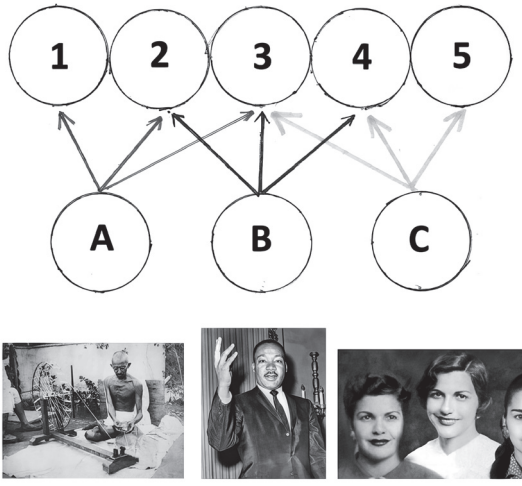
CONDITIONED AND UNCONDITIONED STIMULUS TABLE

CONDITIONED STIMULUS AND THE PEOPLE WHO LABORED TO GENERATE THAT ASSOCIATION	UNCONDITIONED STIMULUS
1. Muslims, according to European nationalists	*a. Vermin, rodents*
2. Jews, according to the Nazis	*b. Thieves, pickpockets*
3. Indo-Pakistanis, according to half the Kenyans I know	*c. Opium addicts*
4. Irish immigrants, according to nineteenth-century WASPs	*d. A malignancy, a cancer*
5. Roma, according to centuries of Europeans	*e. Violent superpredators*
6. Mexicans, according to Donald Trump (this is a freebie thrown in)	*f. Rapists*
7. Young African American men, according to swaths of White America	*g. Shop owners who cheat you*
8. Chinese immigrants, according to nineteenth-century America	*h. Cockroaches*
9. Tutsi, according to the Hutu architects of the Rwandan genocide	*i. Drunken Papists*

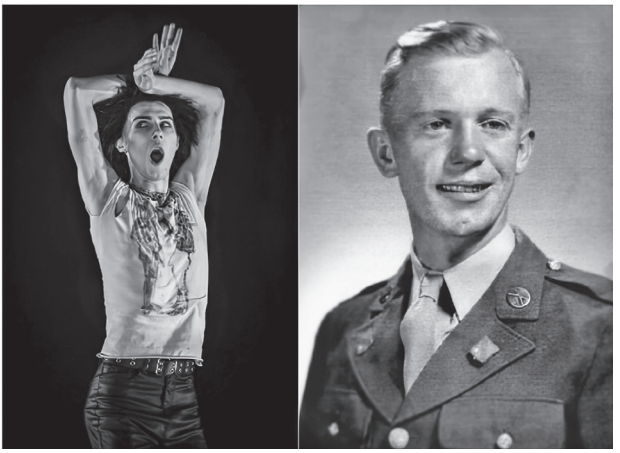
HYPOTHETICAL NEURONAL CIRCUIT DIAGRAM 1

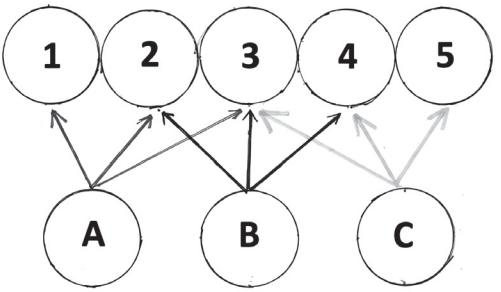


HYPOTHETICAL NEURONAL CIRCUIT DIAGRAM 2

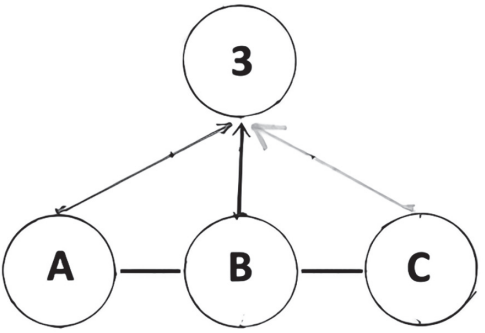


HYPOTHETICAL NEURONAL CIRCUIT DIAGRAM 3

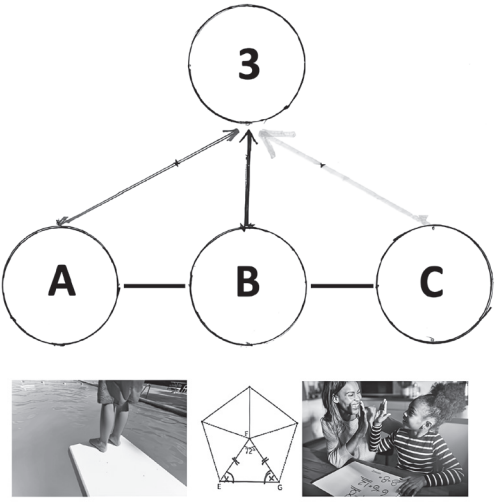




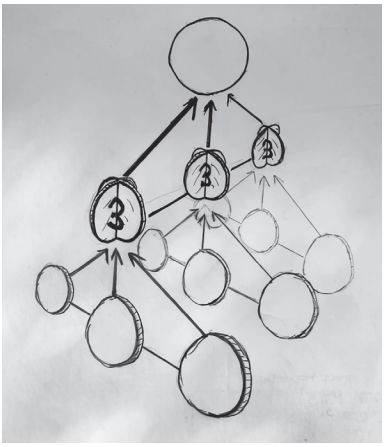
HYPOTHETICAL NEURONAL CIRCUIT DIAGRAM 4



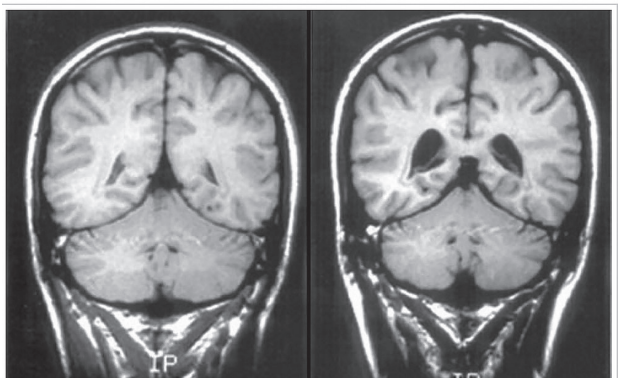
HYPOTHETICAL NEURONAL CIRCUIT DIAGRAM 5



HYPOTHETICAL NEURONAL CIRCUIT DIAGRAM 6



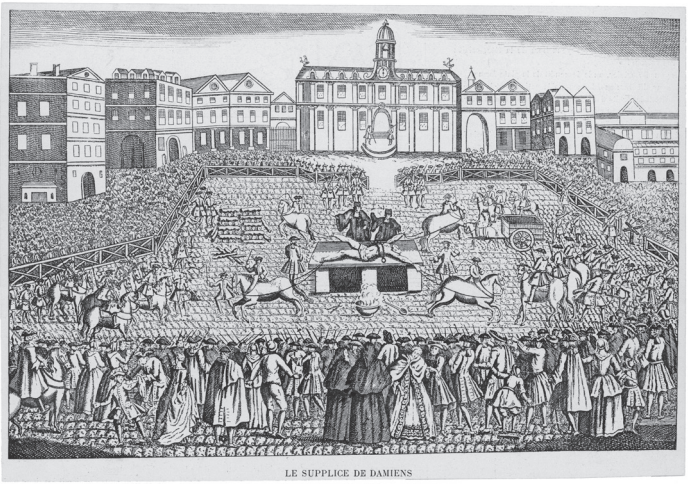
IDENTICAL TWINS BRAIN FIGURE



The photograph displayed by Torrey

PICTURE

PICTURE



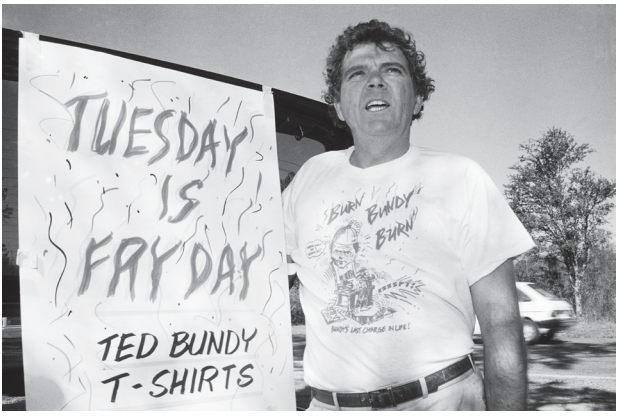
LE SUPPLICE DE DAMIENS

PICTURE

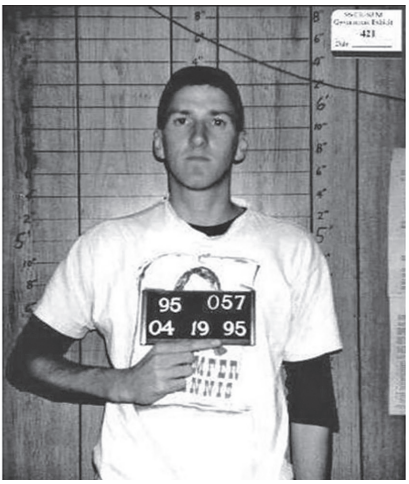
PICTURE

PICTURE

PICTURE

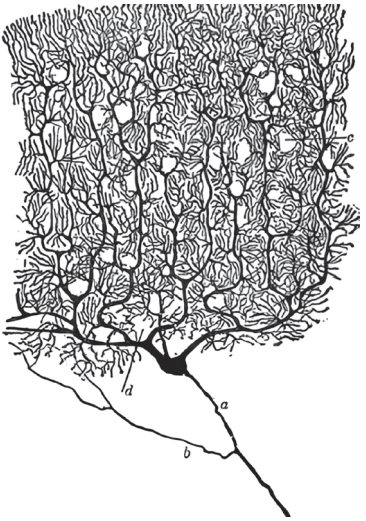


PICTURE

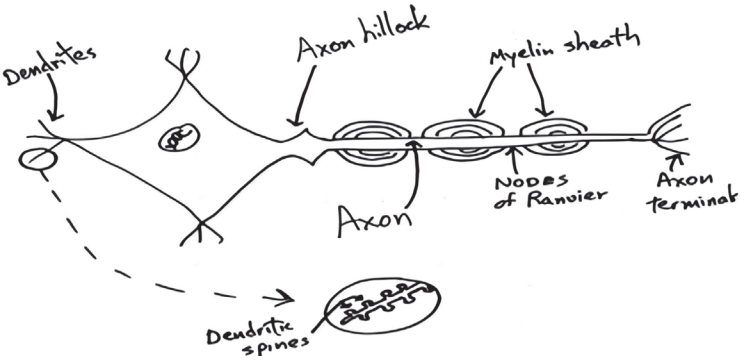


PICTURE

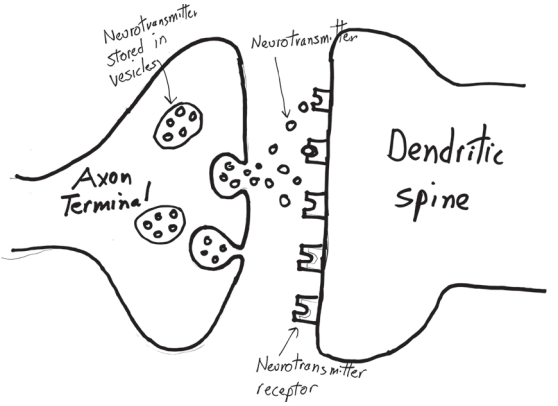
SANTIAGO RAMÓN Y CAJAL
NEURON DRAWING



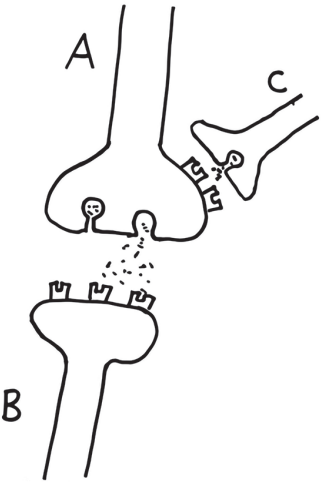
NEURON SUBPARTS DIAGRAM



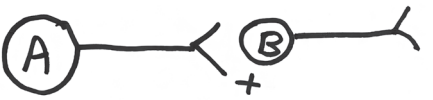
NEUROTRANSMITTER DIAGRAM



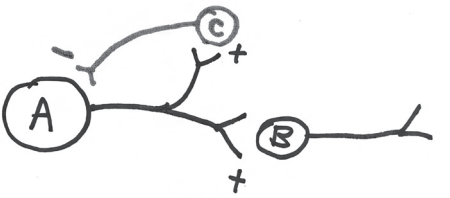
NEUROMODULATION DIAGRAM



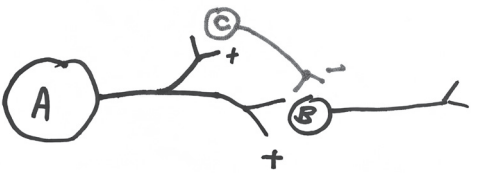
SIGNAL SHARPENING DIAGRAM 1



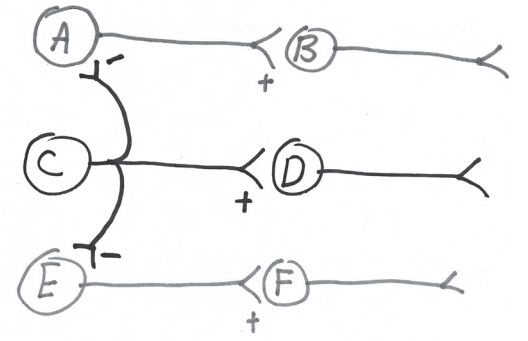
SIGNAL SHARPENING DIAGRAM 2



SIGNAL SHARPENING DIAGRAM 3



SIGNAL SHARPENING DIAGRAM 4



TYPES OF PAIN CIRCUIT DIAGRAM