PHYSICS HELPS SOLVE MEDICAL MYSTERIES

My Career

as a Biomedical Physicist

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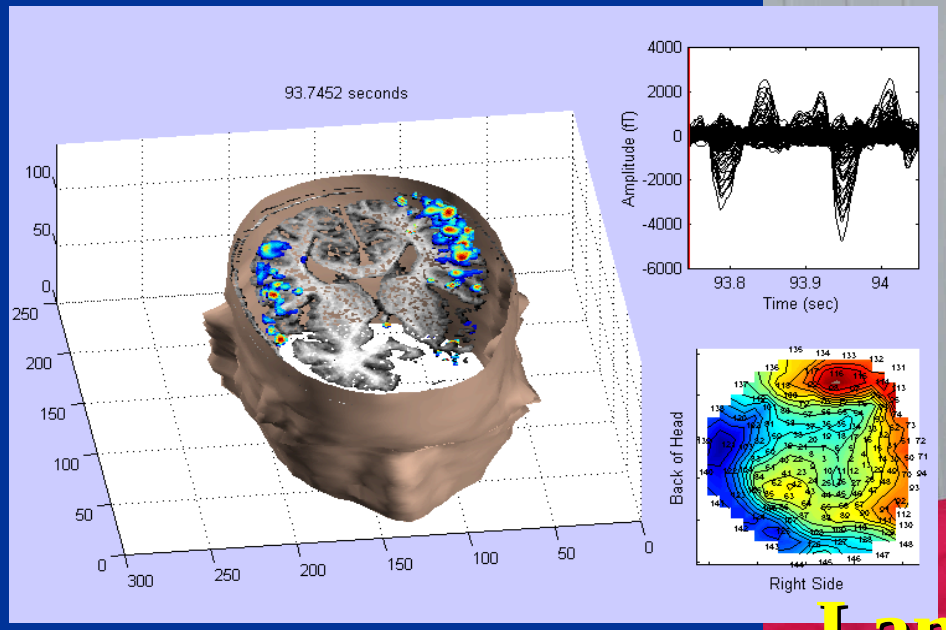
Who am I?

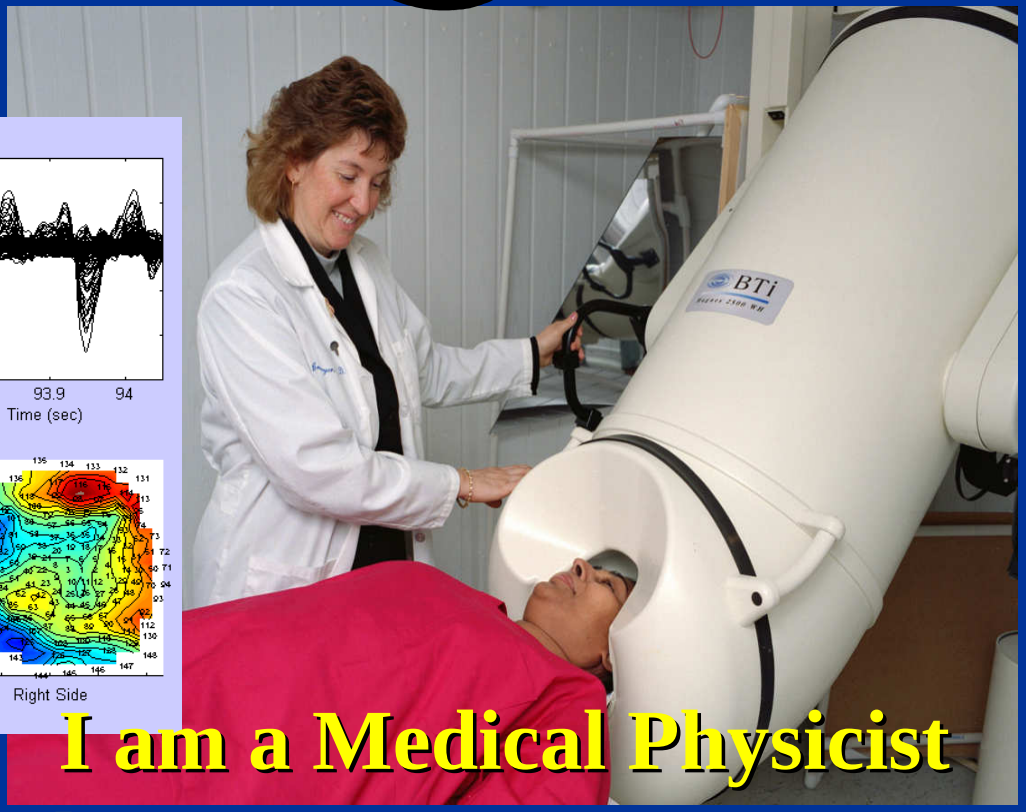
NeuroScientist

Neurology Professor

Physics Professor

Mentor/teacher





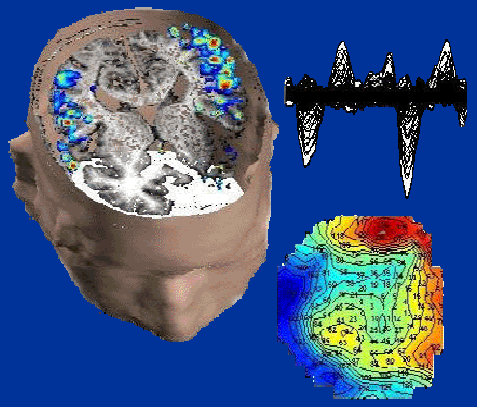
I am a Medical Physicist

Who Can Map YOUR Brain!

Henry Ford Hospital

Outline

- **What is a biomedical physicist**
- **Mysteries of the mind**
- **Brain**
- **Functional imaging techniques**
- **A day in my life**
- **Is Physics in your Future?**



Physics

Physics is understanding:

- how or why things work
- how they came to be

Physicists ask really big questions like:

- How did the universe begin?
- How will the universe change in the future?
- How does the Sun keep on shining?

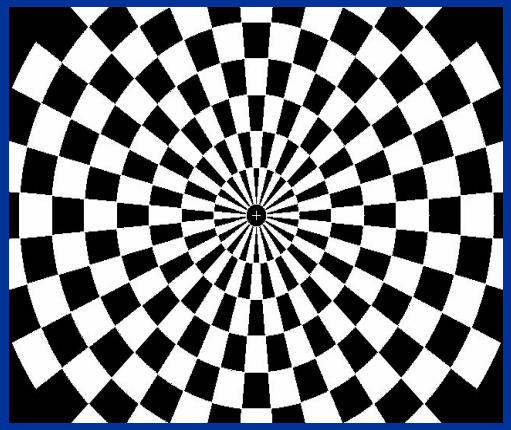
Biomedical Physicists ask questions like:

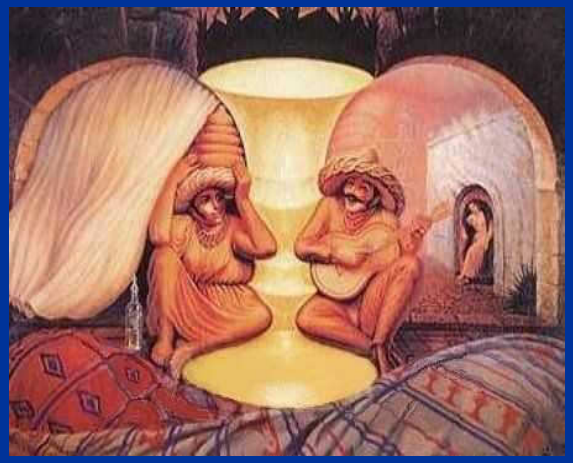
- What causes brain disorders like Epilepsy?
- How does your brain process sounds and words?
- What is the velocity of your blood flow?
- How fast do electrical signals travel in your body?

Mystery
How do you Think?

Cognitive Tasks and Evoked Responses

What do you see?





Where do you feel this?

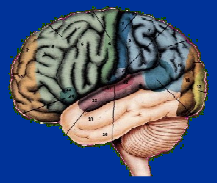
Do they match?

Name the color of the word.

BLUE	GREEN	YELLOW
PINK	RED	ORANGE
GREY	BLACK	PURPLE
TAN	WHITE	BROWN

Stroop Test

BLUE	GREEN	YELLOW	BLUE	GREEN
PINK	RED	ORANGE	PINK	RED
GREY	BLACK	PURPLE	GREY	BLACK
TAN	WHITE	BROWN	TAN	WHITE



How to Save New Brain Cells

Fresh neurons arise in the adult brain every day. New research suggests that the cells ultimately help with learning complex tasks—and the more they are challenged, the more they flourish.

So Challenge your brain:

✓Crossword puzzles
✓Word searches
✓Puzzles

O SOLVE GO TO
tp://www.rubiks.com

W	V	E	R	T	I	C	A	L	L	Week
R	O	O	A	F	F	L	S	A	B	Find
A	C	R	I	L	I	A	T	O	A	Random
N	D	O	D	K	O	N	W	D	C	Sleuth
D	R	K	E	S	O	O	D	D	K	Backward
O	E	E	P	Z	E	G	L	I	W	Vertical
M	S	I	I	H	O	A	E	R	A	Diagonal
A	L	R	K	R	R	I	R	E	R	Wikipedia
K	O	D	I	D	E	D	R	C	D	Horizontal
H	E	L	W	S	L	E	U	T	H	Word Search

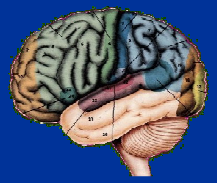
The Human Brain

3 pounds of the most complex matter known to man.

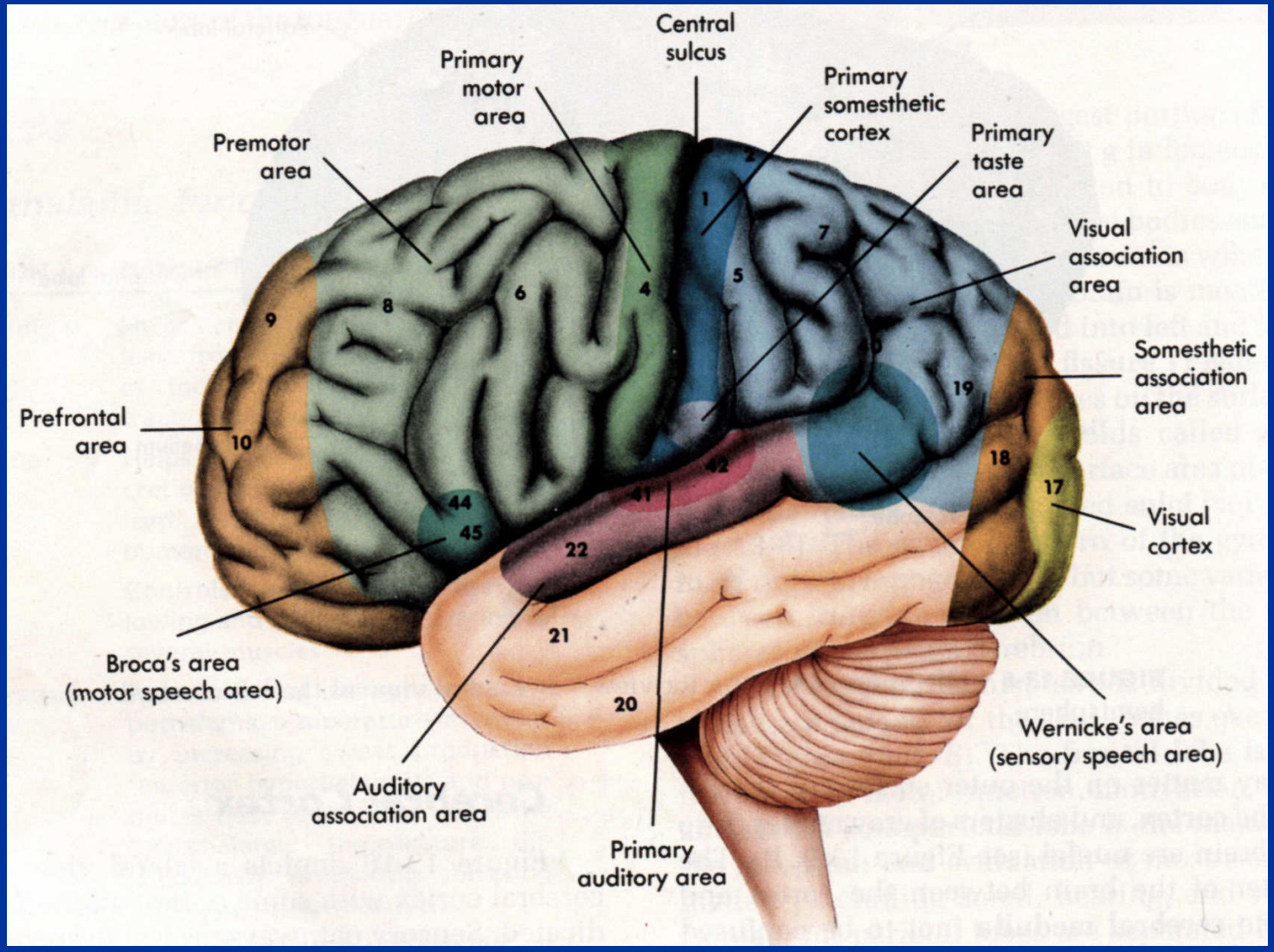
Your brain is responsible for everything that you have done in the past, and everything you are doing now and everything you will do in the future.

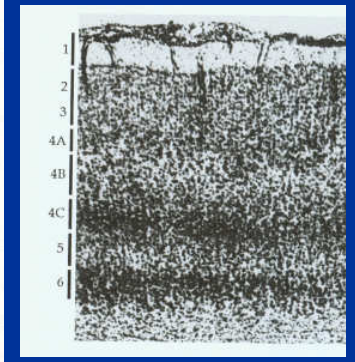
Your brain also receives information from the outside world and from inside your body. In response to this information, your brain sends signals to muscles and glands to control your behavior. So you can read, write, remember, cry, laugh, run, talk - that's your brain working.

Helmets are very important, because we cannot replace YOUR BRAIN.

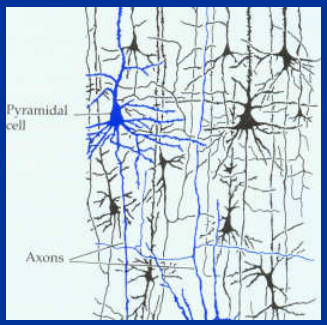


Human Brain

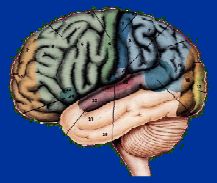




cortical tissue slice

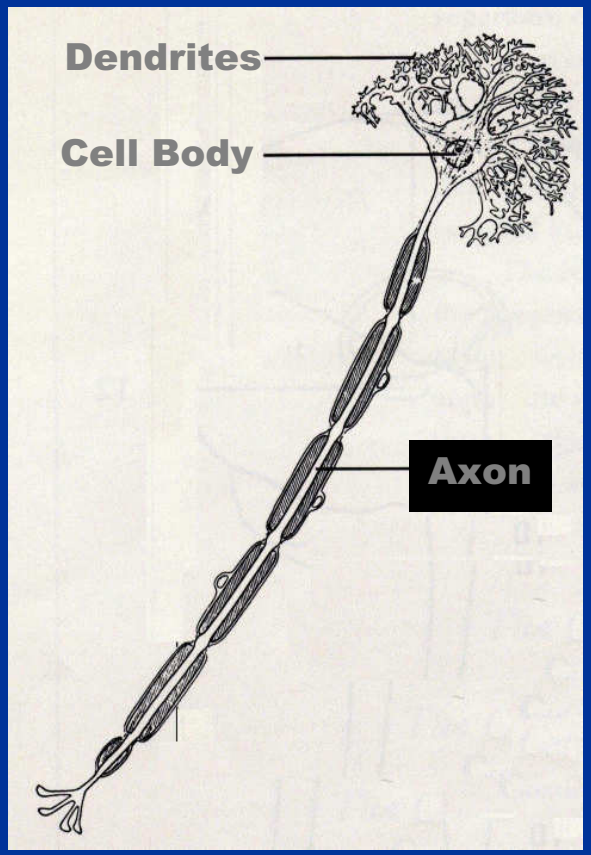


Cells lined up in the cortical surface



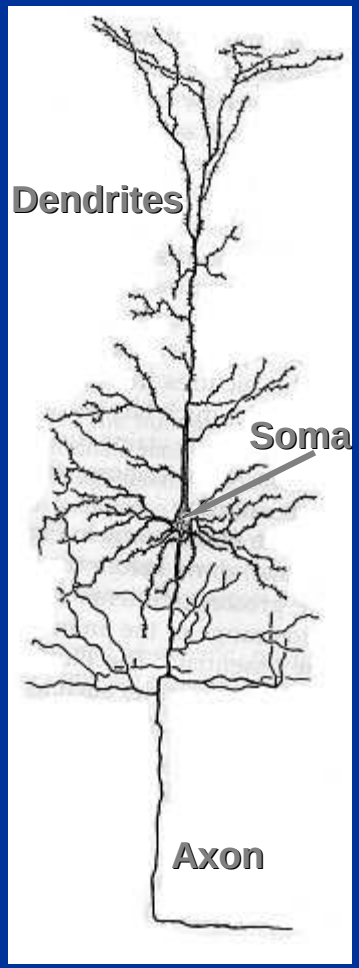
The Neuron

Pyramidal cell



Neurons consists of 3 parts

- **The cell body contains the nucleus where metabolism occurs.**
- **The dendrites receive messages from other nerve cells.**
- **These signals travel down the axon to other nerve cells.**

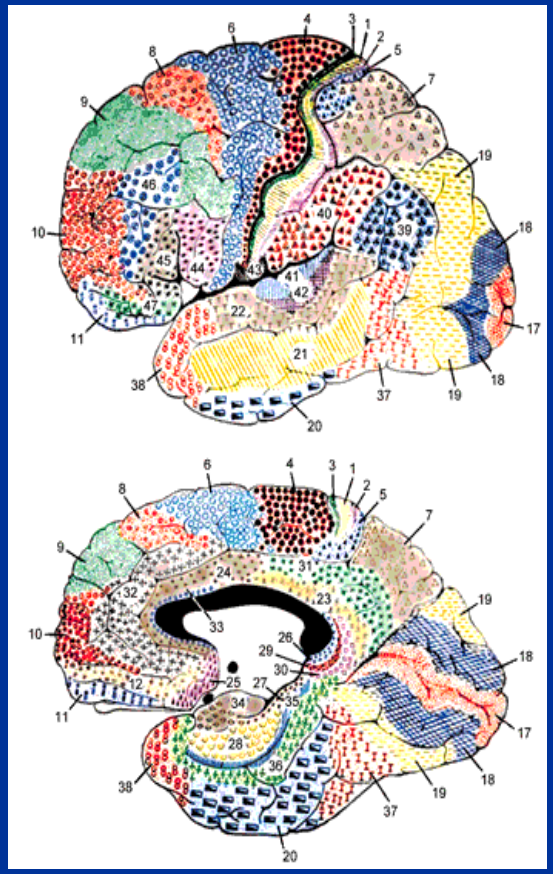


Approximately how many neurons does the brain contain?

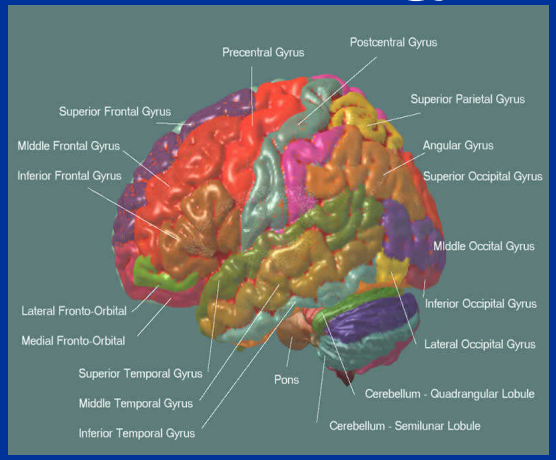
100 billion

Neuroscientists Map the Human Brain

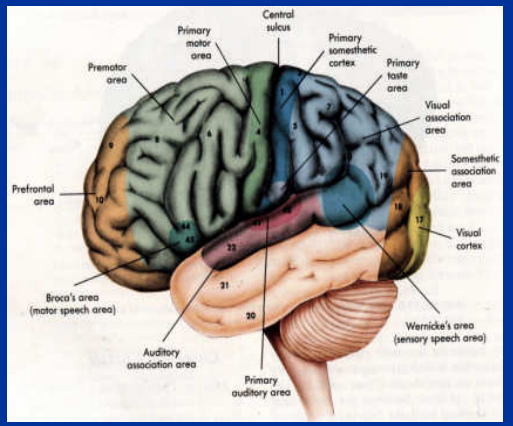
Brodmann's area Maps



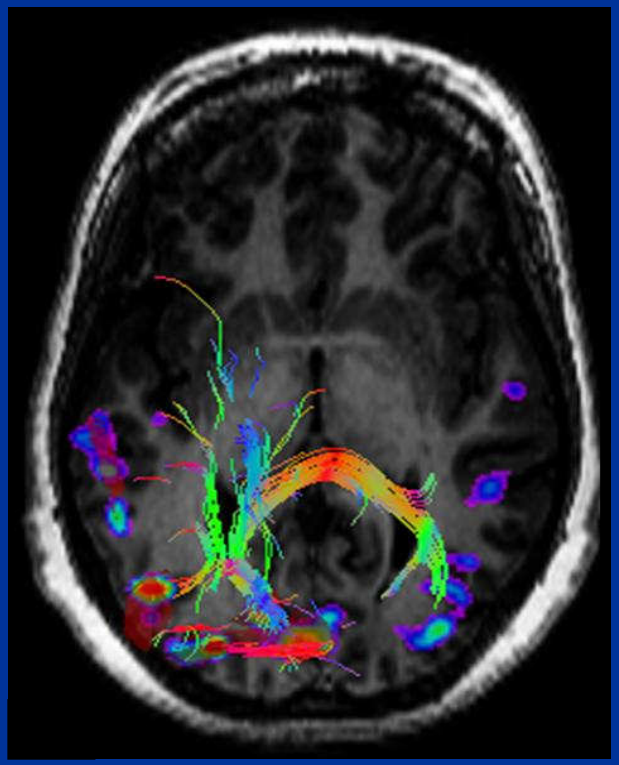
Color coded gyri



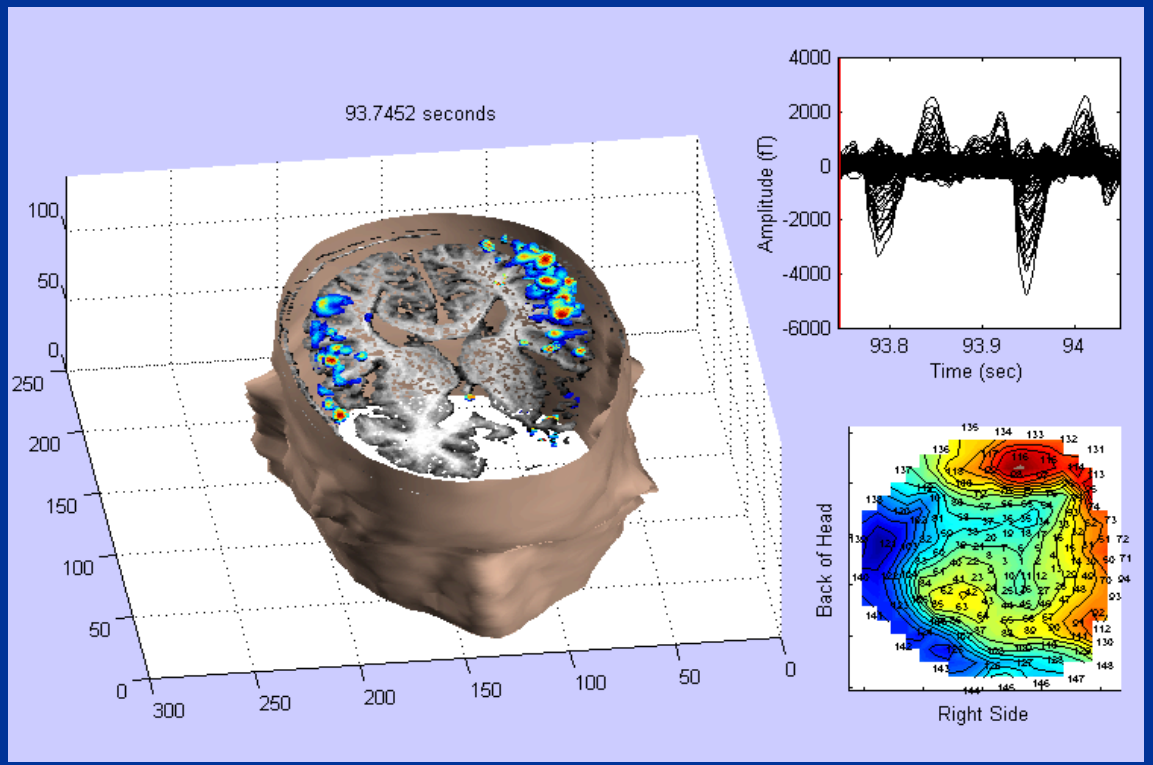
Standard Areas



Integrated Imaging of the Brain

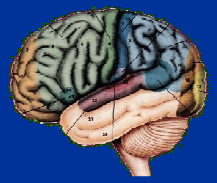


This image displays the fiber tracks, several active functional areas, and the underlying anatomy.

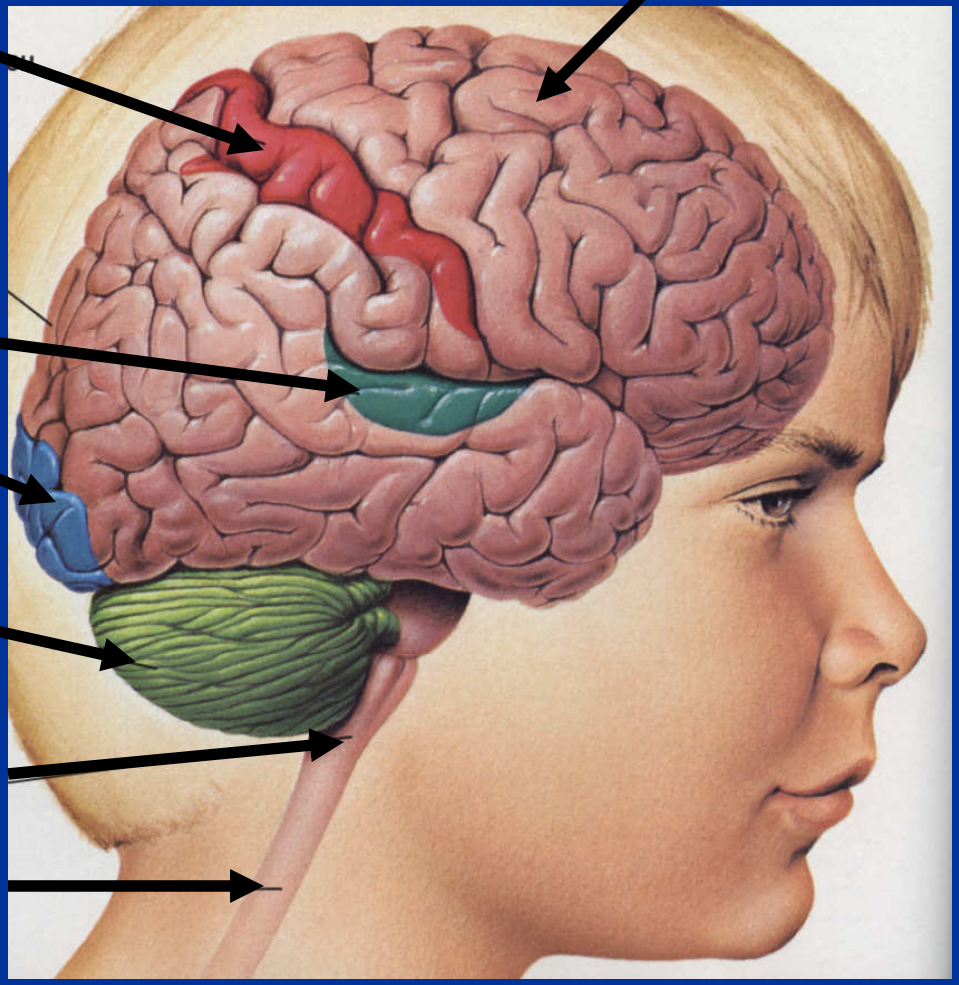


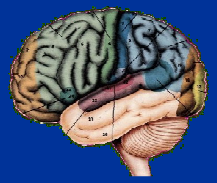
This image displays the millisecond to millisecond cortical activations during an epileptic seizure.

Building road maps of the brain



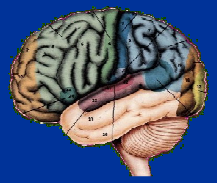
Parts of your brain





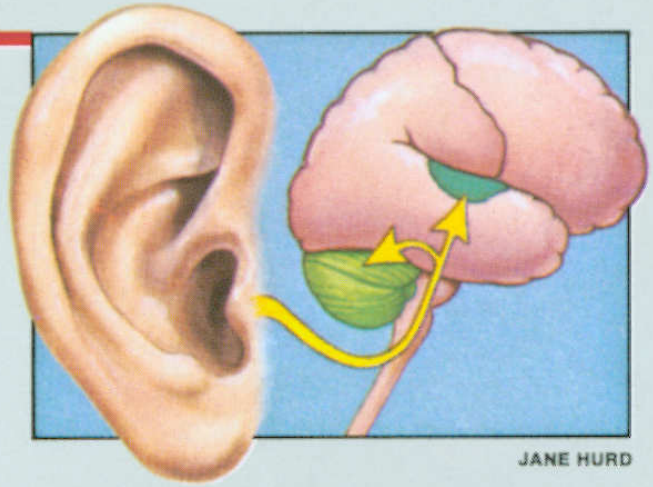
What are your 5 senses?

- ✓Smelling 
- ✓Seeing 
- ✓Tasting 
- ✓Hearing 
- ✓Feeling 



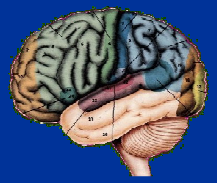
Hearing and Balance

Your sense of hearing helps you communicate through speech. In addition to hearing receptors, your ears contain organs that help your brain give you a sense of balance.



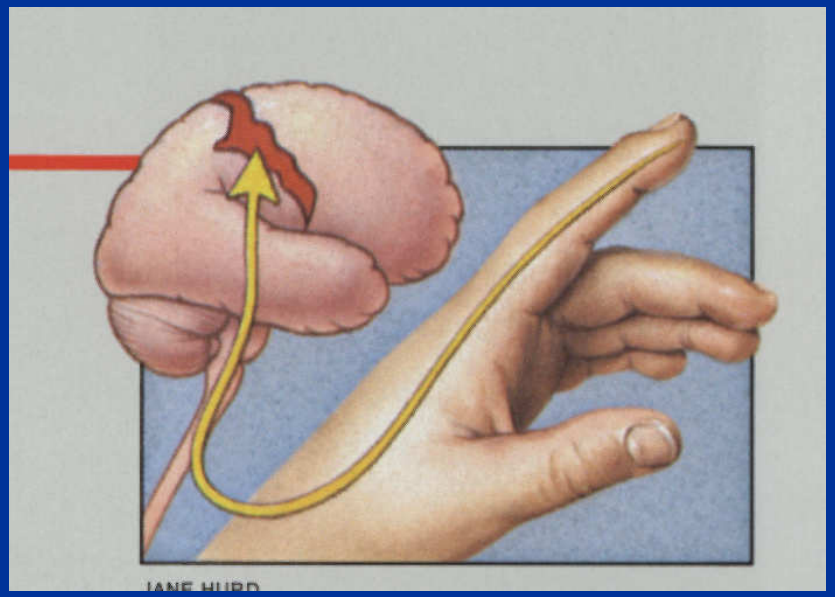
JANE HURD

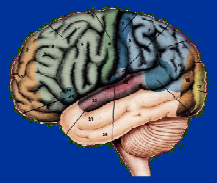
HEARING (DARK GREEN) AND BALANCE (LIGHT GREEN) CENTERS OF THE BRAIN

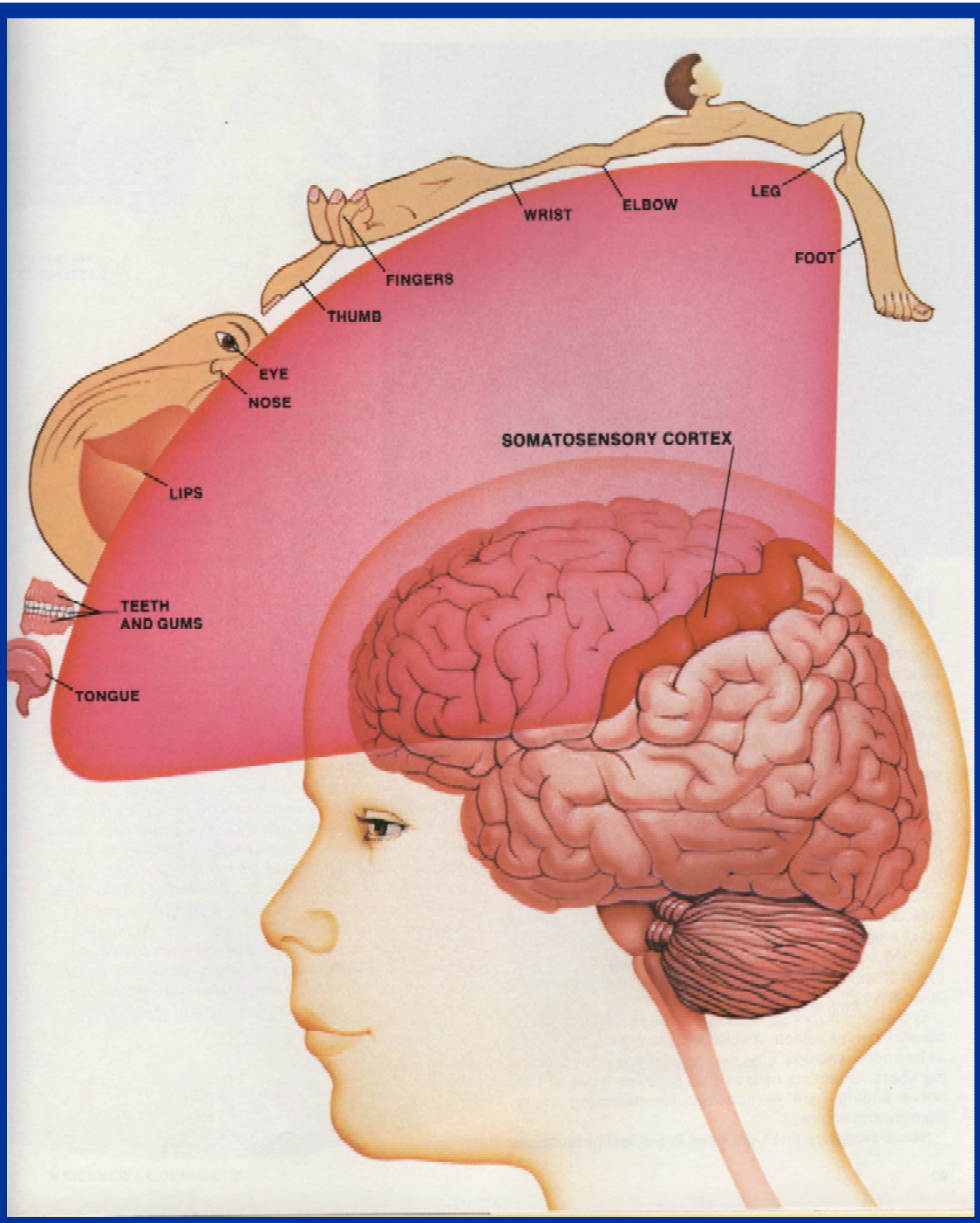


Touch: Messages of Feeling

Sense receptors in your skin allow you to feel the world around you. In addition to the experience of touch, these receptors enable you to feel pain, warmth, and coolness.

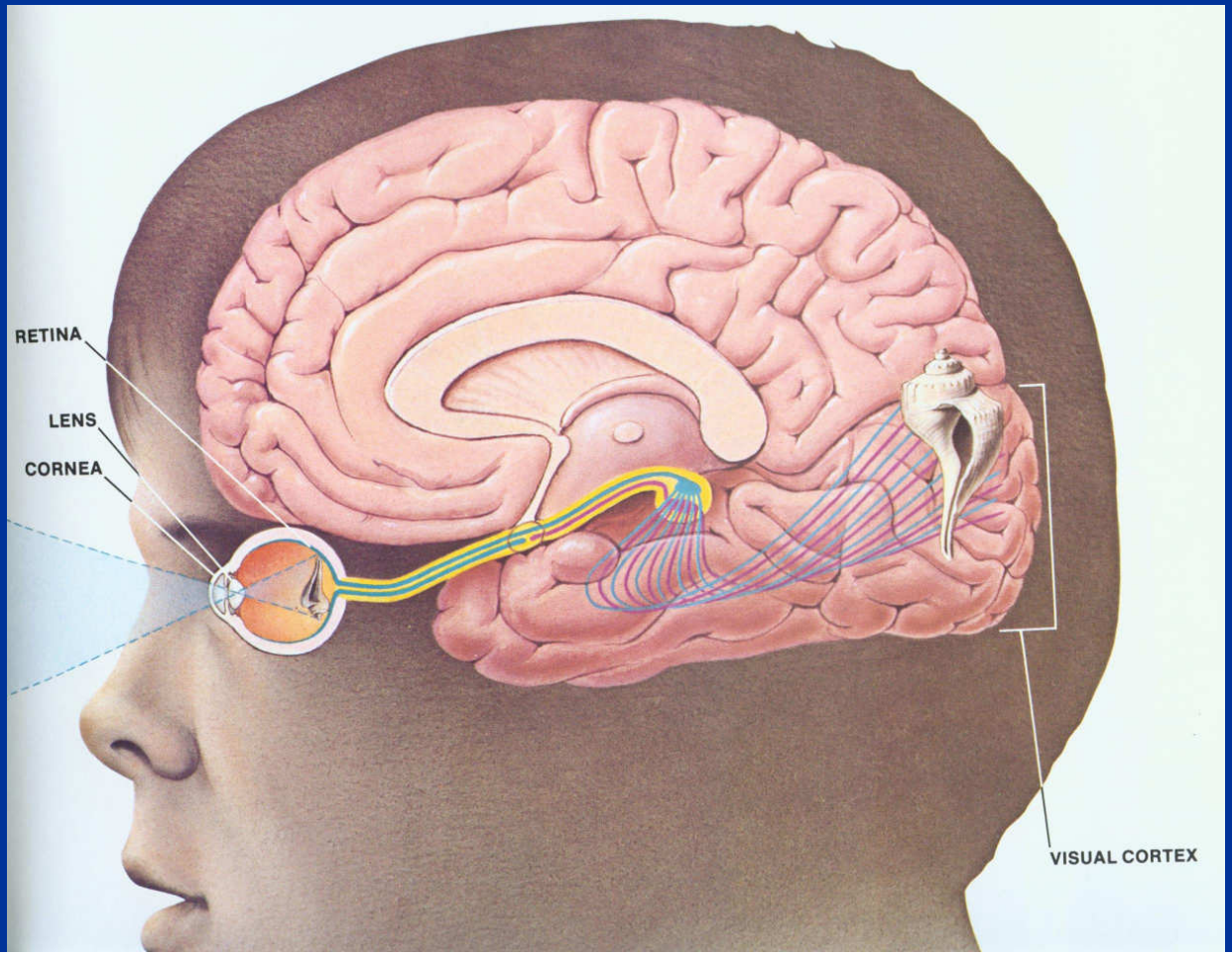





LEG
ELBOW
WRIST
FOOT
FINGERS
THUMB
EYE
NOSE
SOMATOSENSORY CORTEX
LIPS
TEETH
AND GUMS
TONGUE

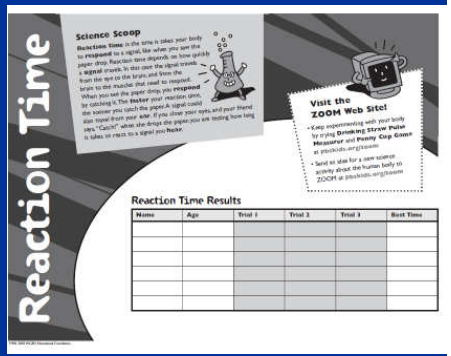
Vision: Sending images to the brain

Our eyes gather more information about our surroundings than does any other sense organ. In nearly every thing we do- reading, writing, playing-we depend on our eyes



Measure your nerve conduction response times

Tell your friend that when you release the ruler they are to grab it as fast as possible. Place your elbow near the edge of the table so that your wrist can extend over the side of the table. Do not make any sounds or gestures that you are releasing the ruler. They have to react to the visual stimulus of seeing the ruler being released.
Record the centimeter mark. Repeat the experiment three more times. Then switch places with your partner and redo it.



The average reaction time for humans is 0.25 seconds to a visual stimulus, 0.17 for an audio stimulus, and 0.15 seconds for a touch stimulus.

Physics and Math to get the reaction time

In Physics we use the kinematic equations to determine how fast the paper drops.

$x = vt + \frac{1}{2} a t^2$

We then use this algorithm to calculate your reaction speed is
where
x = distance in meters
v = initial velocity (the paper being held at rest is 0)
a = acceleration due to gravity = 9.81m/s²
t = time in seconds

We need to manipulate $x = vt + \frac{1}{2}at^2$ to give us an algorithm for time (t)

As v = 0 then vt = 0 therefore

the algorithm is $x = \frac{1}{2} at^2$ which can be rearranged $t = \sqrt{(2x/a)}$

For Example

x = 9cm
t = sqrt(2 × 0.09 ÷ 9.81)
t = sqrt(0.01835)
t = 0.135 seconds

Nerve conduction Velocity (v=d/t)

- Nerve conduction velocity is the speed at which an electrochemical signal propagates down a neural pathway. A signal can travel from the nerve endings to the brain and back at a speed of 25 meters per second or 1 meter in 0.04 seconds.
- Nerve conduction velocity are different between humans and animals.
- In humans it varies
  - Muscles is 119m/s (very fast)
  - Touch is 80 m/s (fast)
  - Pain is 0.61m/s (slow)
  - Thinking 20-30 m/s
- So how far did your nerve conduct the signal.
  - Measure from you occipital cortex to the base of you neck and then down you arm. (adults is about 36 inches x 2.54cm/inch =91cm) 100cm=1meter 91cm=.91meters

The average reaction time for humans is 0.25 seconds to a visual stimulus, 0.17 for an audio stimulus, and 0.15 seconds for a touch stimulus.

Brain IMAGING

Devices

Developed by Physicists

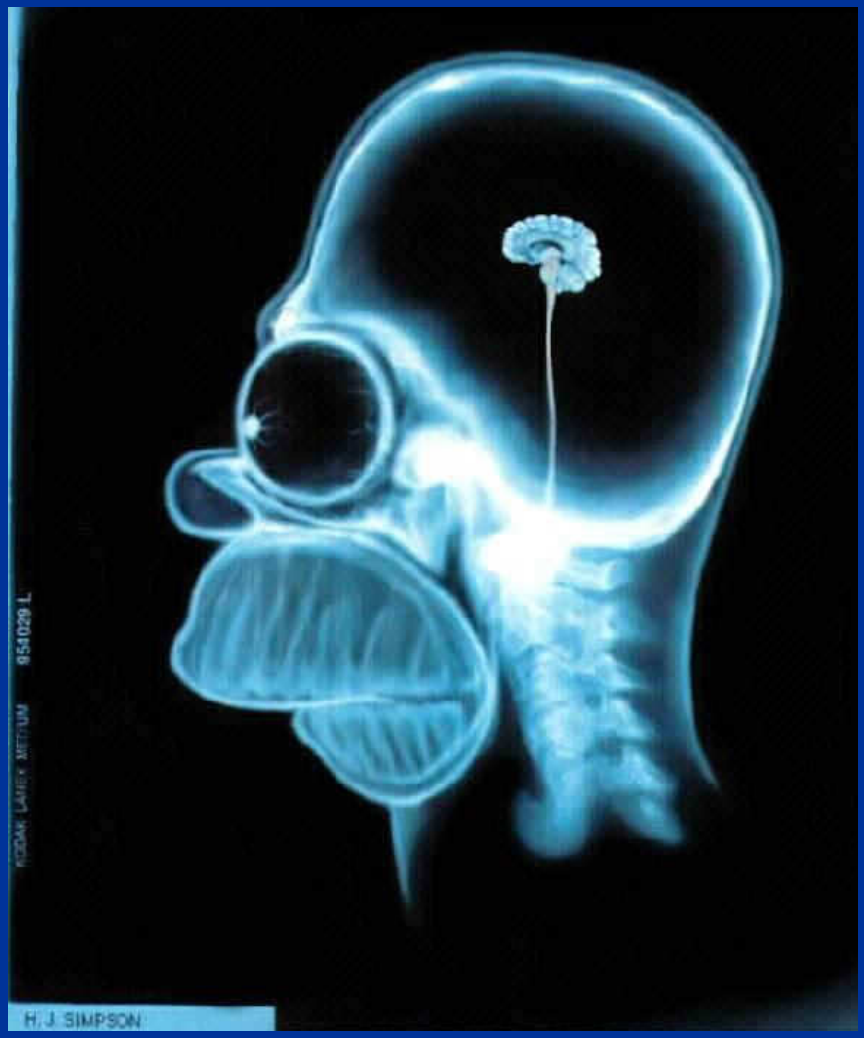
X-RAY

X-rays are produced by accelerating electrons.

The X-rays are blocked by dense tissues such as bone and pass through soft tissues.

Where the X-rays strike the photographic plate it turns black when it is developed. So where the X-rays go through "soft" parts of the body like organs and skin the plate turns black.

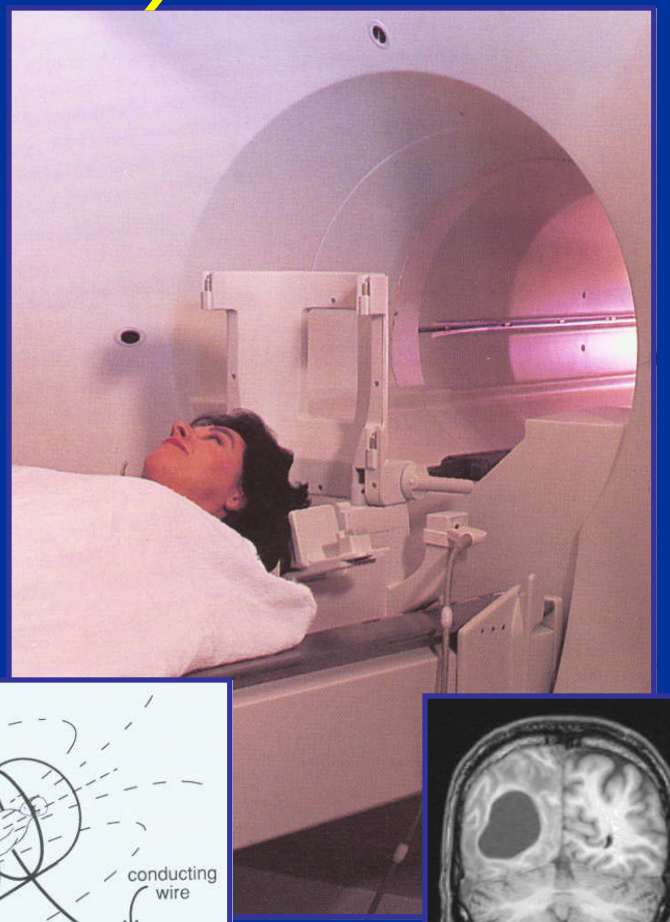
USED to find bone fractures or breaks

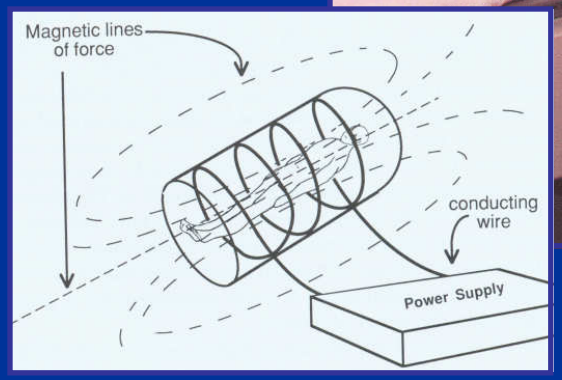


Magnetic Resonance Imaging (MRI)

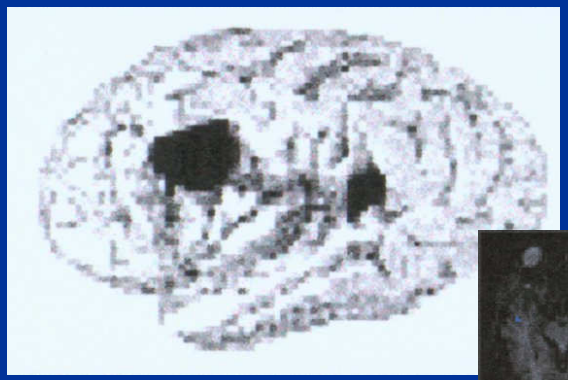
A technique for imaging different structural anatomical tissue types by placing a subject in a strong static field and measuring the relaxation rates of different tissues after absorbing radio waves at specific frequencies.

USED – find tumors



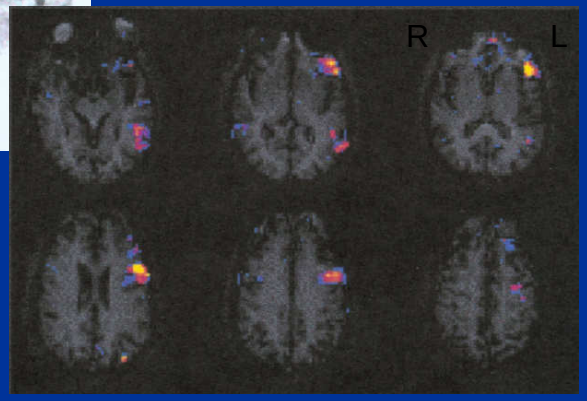


Functional Magnetic Resonance Imaging (fMRI)

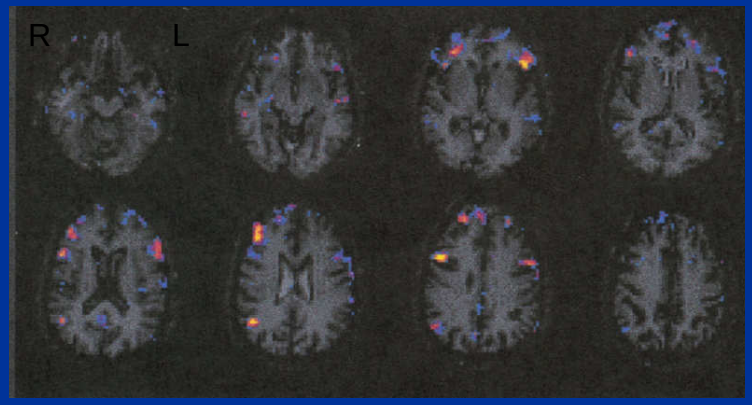


Semantic decision making task

Right handed subjects
left hemisphere activation



Left handed subjects
bilateral activation



Kanowski, Fernandez,Heinz, Rotte, Bonn Medical Center, Germany, Human Brain Mapping 2001

A technique for measuring blood oxygenation of specific tissue during a task.

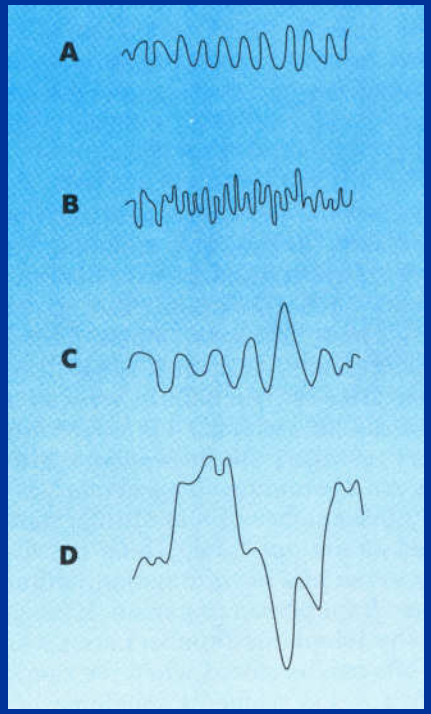
Pixel activation is overlaid onto an MRI scan

Electroencephalography (EEG)

A technique for recording electrical brain activity arising from neuronal activation by placing electrodes on the scalp.

Amplitude – microvolts

USED – find epilepsy



Alpha (8-12 Hz)

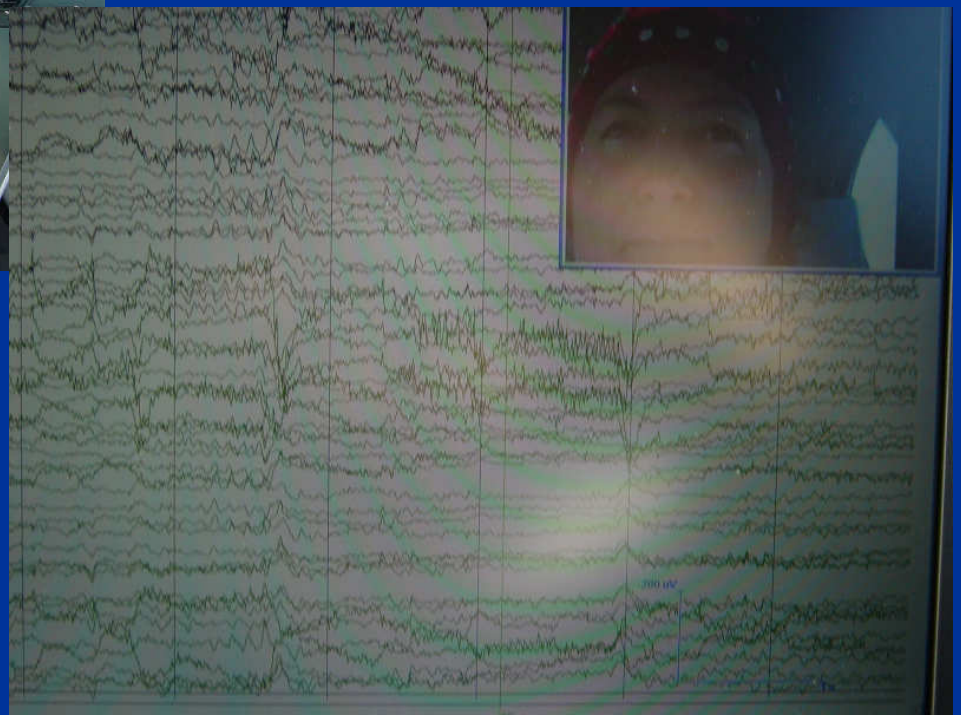
Beta (13-30 Hz)

Theta (4 - 8 Hz)

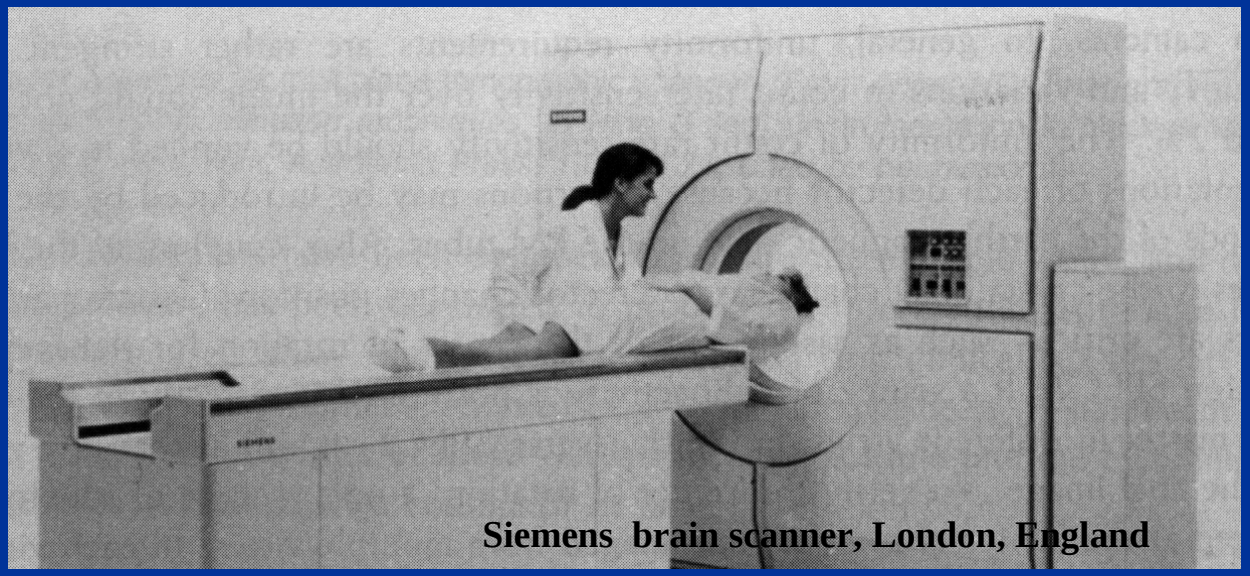
Delta (< 4 Hz)

Gamma (> 30 Hz)

Our Next Frontier On Road driving with EEG



Positron-Emission Tomography (PET)



Siemens brain scanner, London, England

A technique for studying the metabolism of the brain, by using positron emitting isotopes ^{11}C, ^{13}N, ^{15}O, and ^{18}F labeled molecules in solution and injected into a subject.

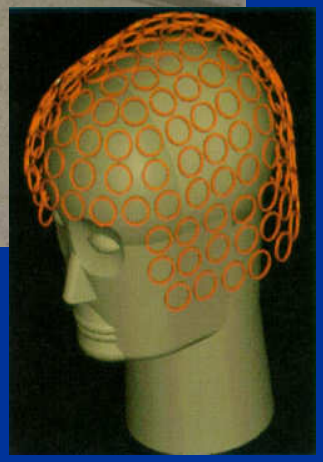
Semantic-Letter categorization task

Magnetoencephalography (MEG)

A technique for localizing sources of electrical activity within the human brain by non-invasively measuring the magnetic fields arising from such activity.

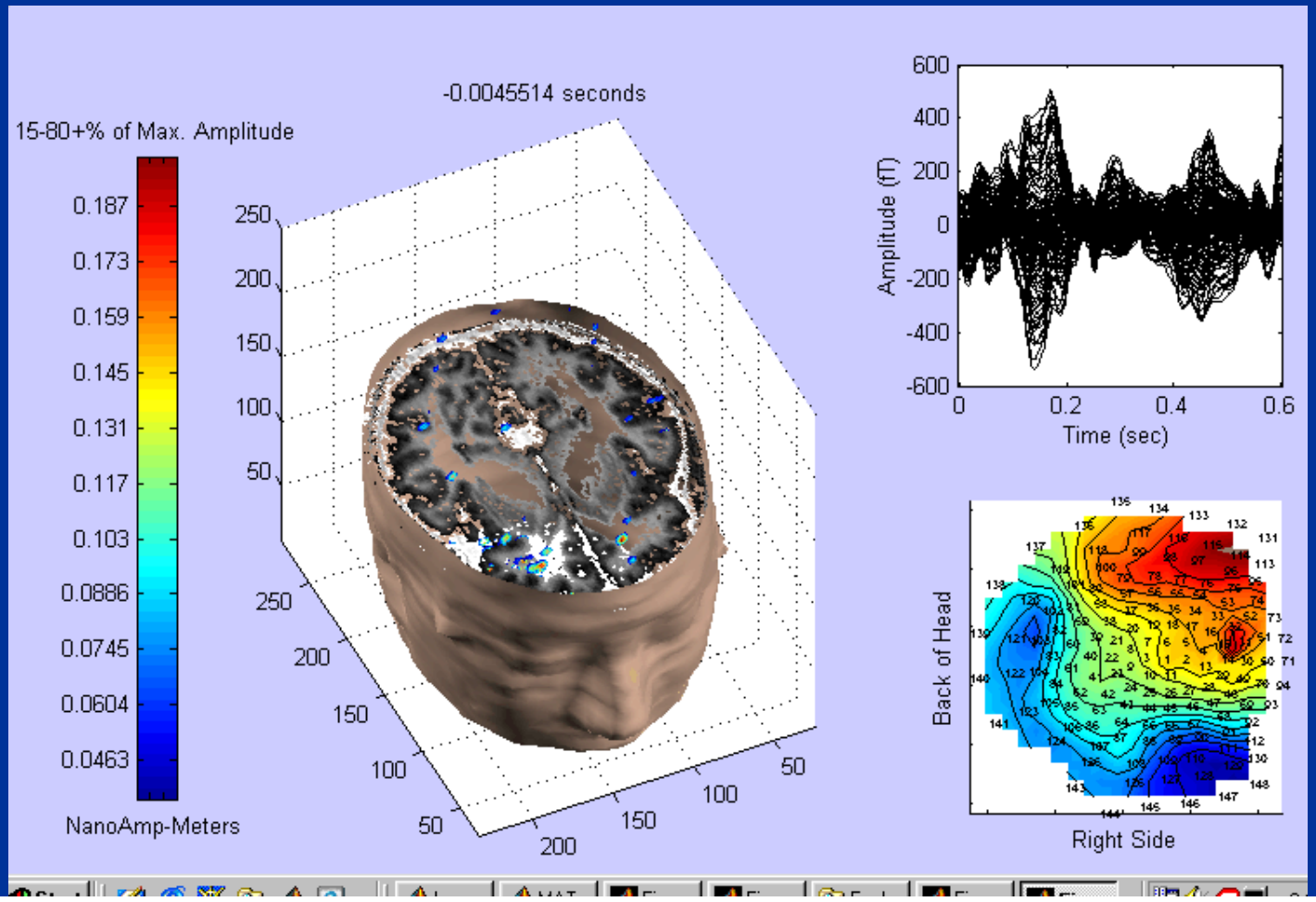
MEG correlates function and anatomy with millisecond temporal resolution and millimeter spatial resolution

Henry Ford Hospital



Time Evolution of Language Processing by MEG

Normal Reading Subject during: Picture Naming



A Day in My life

- **Data collection**
- **Data analysis**
- **Write grants**
- **Write papers**
- **Discuss new studies**
- **Administrative paper work**
- **IRB renewals**
- **Talk to other researchers**
- **Oversee Graduate students and Medical students**
- **Listen or Present Lectures**

OU OAKLAND UNIVERSITY MAGAZINE

Using biomagnetic signals, physicist can map what's on your mind

Susan Bowyer, Ph.D '98, jokes that life experience helped her get into the doctoral program in biomedical sciences with a specialization in medical physics at Oakland University. After all, this mother of an 11-year-old son also worked at a bank while earning a bachelor's degree in applied science from the University of Michigan — she knows self-discipline. Having lived on a farm near Imlay City, Mich., for years, she had no trouble with animal research. And as a licensed pilot, she had an instinct for physics.

Susan Bowyer, Ph.D. '98, has gained international recognition for her work with magnetoencephalography, a brain scan used for sensory mapping.

Since earning her doctorate from OU in 1998, it's her career that's been soaring. As a senior staff biomedical investigator at Detroit's Henry Ford Hospital, the Rochester Hills resident has gained international recognition for her cutting-edge work with magnetoencephalography (MEG), a non-invasive brain scan used for sensory mapping.

MEG examinations in the clinical setting help neurologists and neurosurgeons locate functional brain tissue surrounding lesions and localize the source of seizures. They also help determine the safest way to enter the brain if surgery is needed. MEG can also help surgeons determine what complications a patient may have after surgery based on the areas of the brain involved. Bowyer's research using MEG has included looking at brain pathways that may contribute to dyslexia, depression, migraines, epilepsy and even driver distractibility.

One of about 200 women in her field, Bowyer is active in encouraging young women to enter the sciences and was featured along with astronaut Sally Ride in "Physics in Your Future," a brochure produced by the American Physical Society.

"The job I have is so interesting and it changes all the time," says Bowyer, 43. "It's a good feeling to know that the research I do may be helpful to someone tomorrow."

A frequent speaker at national and international conferences, Bowyer recently presented her research findings to the American Epilepsy Society at its annual conference in Washington, D.C., and was invited to present about brain mapping at a conference in Florence, Italy, this June.

Bowyer credits OU Physics Professor Norman Tepley with sparking her interest in neuromagnetics. "He was one of the first to work in the field, and to be working with him while the field was developing was a great opportunity for me."

By Alice Rhein, a freelance writer from Huntington Woods, Mich.

Fall 2006

Lectures around the world

London England

Sendi, Japan

Florence, Italy

Helsinki, Finland; Jena, Germany: Barcelona, Spain

Paris, France

Great Barrier Reef, Australia

Athens, Greece

A Week in the Life of a Scientist

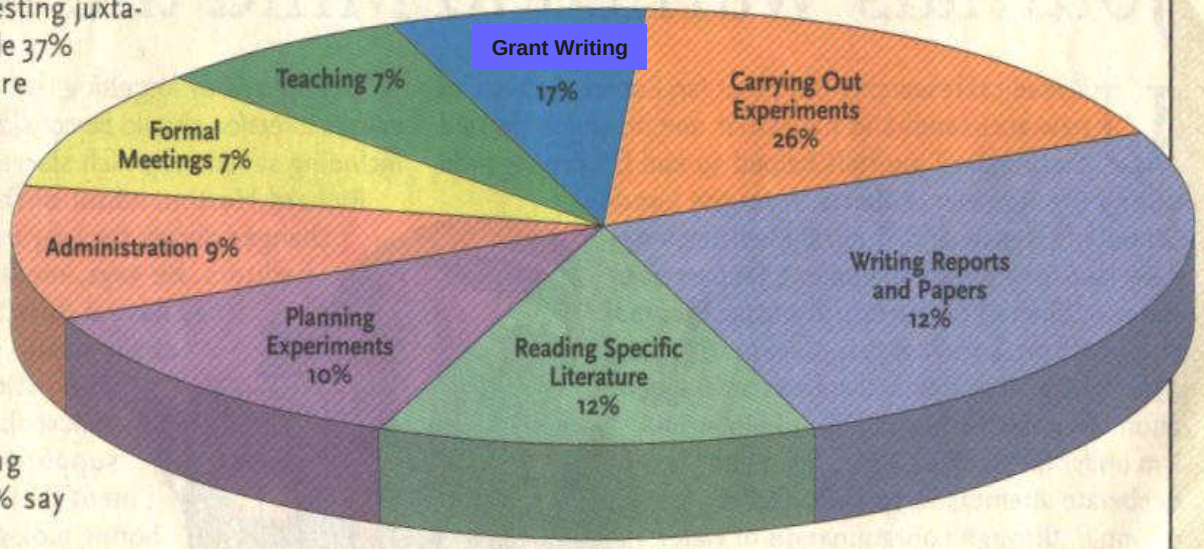
It's about multitasking—and spending serious time at work

Our latest Snapshot survey reveals that 347 of our readers spend an average of 52 hours per week working. The range is large, from a sweatshop level of 95 hours to an enviable 30.

Our readers spend their time on the predictable tasks, with performing experiments, writing, and reading requiring more than 50% of their time. However, some interesting juxtapositions pop up: While 37% say they spend more time planning experiments than they did five years ago, 55% say they spend less time actually doing them. Are graduate students making up the difference here?

On average, scientists are not getting busier: Although 41% say they are spending more hours at work now than they were five years ago, 21% says their hours have decreased, and the balance report no change.

Interestingly, the much-maligned task of grant application and administration is relegated to the "Other" category, occupying just 5% of our scientists' working lives.



The Scientist May 2003

Associates Degree
Macomb Community College

Business Management

Associates Degree 1985-1988

Bachelors of Applied Science
University of Michigan - Flint

Psychology

Bachelors 1989-1992

Doctor of Philosophy (Ph.D.) Oakland University

6 years to complete:

- 3 years of classes before Qualifying exams

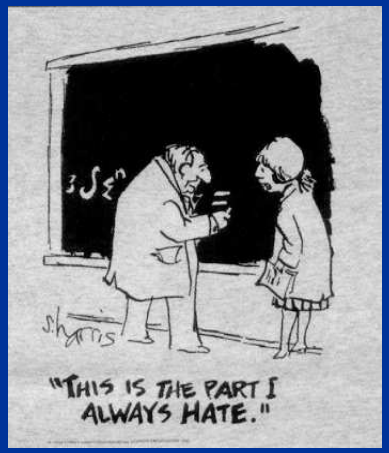
I Failed one section on Recombinant DNA and had to retake it the following year

- 3 years working on dissertation (1 year in Albuquerque, New Mexico)

Physics department

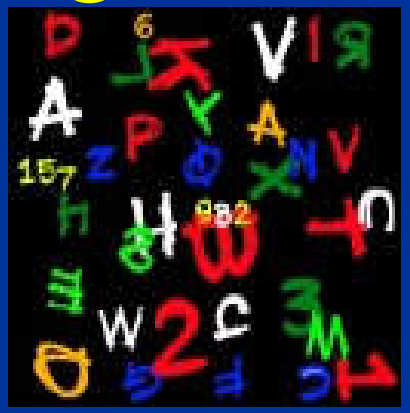
What were my challenges?

- **Learning disorder**
- **High school guidance counselor**
- **Failures**
- **Life experiences**



Don’t give up!!

I was Diagnosed with Dyslexia, a learning disorder, in 3rd grade



Dyslexia is difficulties with accurate word recognition and poor spelling.

There's no cure for it, but there are ways to approach learning and be

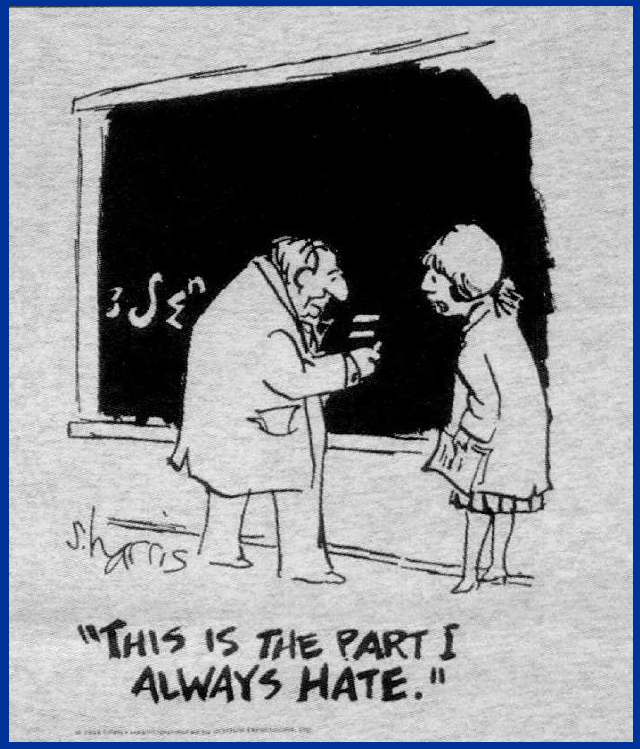
successful!

Failure Happens

I failed 9th grade Algebra

But I received an A+ on the retake in 10th grade.

A different teacher helped!



Learn from your failures and move on!

Don’t ever give up your dreams!!!

- **ACT/SAT scores are intended to measure critical thinking skills for solving problems in college.**
- **They are just numbers.**

Keys to success

- ✓Know that you are valuable
- ✓Trust yourself
- ✓Surround yourself with people who make you better
- ✓Talk less listen more
- ✓Play - have fun
- ✓Write down your goals (have a plan)

5 M.A.G.I.C. keys to success

by Donovan Grant

M for Motivation- This is the most important rule. When at your best, happiest and smartest you will normally be motivated. Remember how it feels. Top tip: Keep a journal of your 'motivating moments' and use it when you need to motivate yourself. (I remember my feelings the first time I flews a plane, scored a goal, got an A+ on an Exam.)

A for Assertiveness-. Having an uplifting belief in yourself and others will believe in you too. Go about creating a "CAN DO" attitude, a positive self image and a feeling of being in control. It is quite normal to occasionally feel nervous about what you say, do, think or feel. Top tip: Create yourself a mantra and say aloud it 10 times when you wake up and before you go to sleep. "I am me, I am enough, I am more than enough, I will always be enough.“ or “ I am fine and I am good”

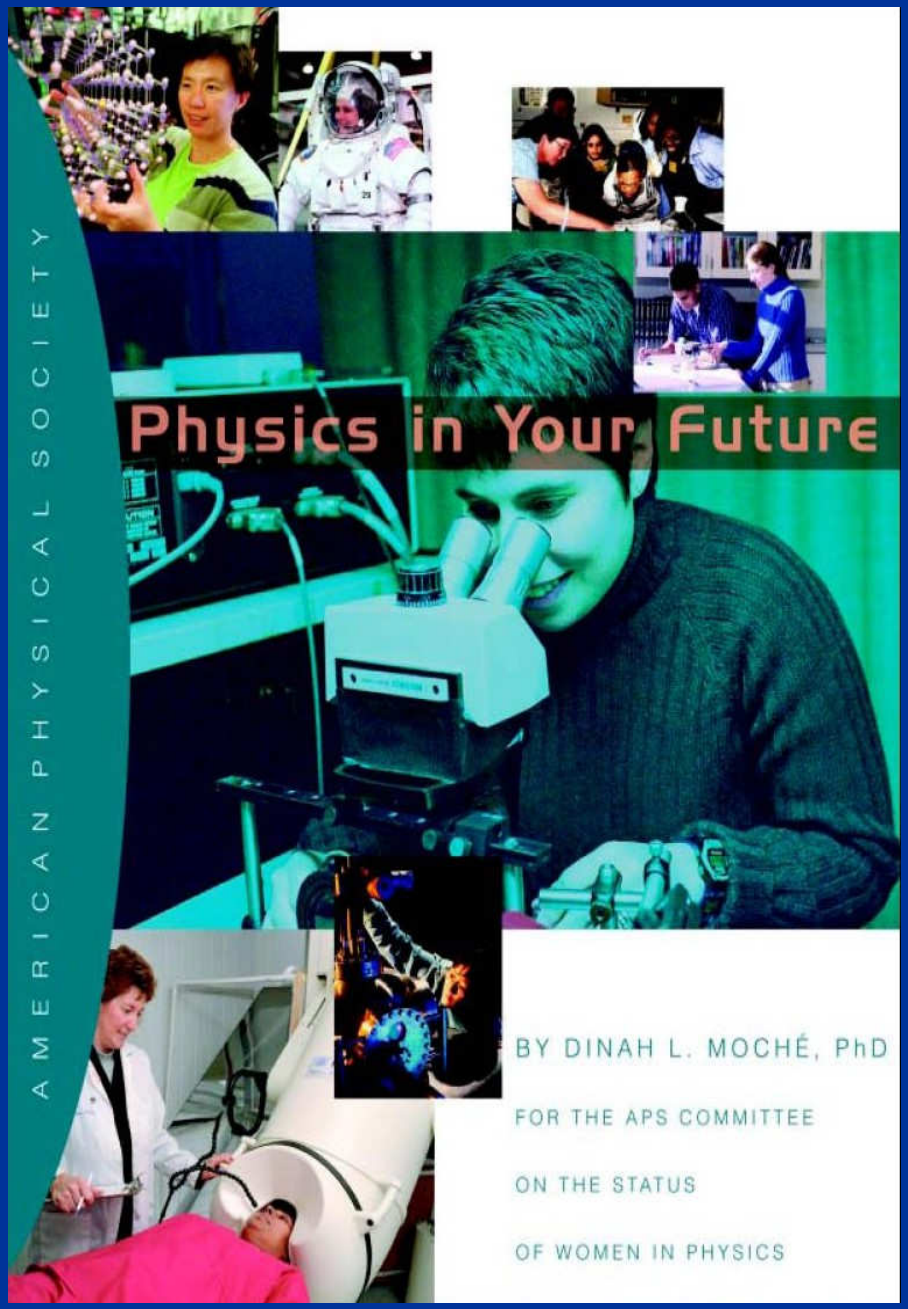
G for Goal Setting- Set yourself a goal to achieve something that you desire. Make it something that would challenge and excite you to achieve it. Then just go for it! When you reach the goal you will experience a huge satisfaction. The best bit is that you will increase your self-belief by what you had to go through to achieve the goal.

I for Initiative -Initiative is about making choices that you think are the best in any given situation. Every time that you make a choice you strengthen your initiative muscles based on the outcome. If some outcomes that you get are not what you desire, make a different choice next time and see what that opens up for you. Take the imitative.

C for Communication-Communication is one of the top skills to develop for any young person. Universities and employers are keen to test your competency and see how well you communicate and interact with other people.
As communication is a thing that is done every day, here are three top tips to improve your art:

1. Build rapport with people - Try talk in a similar tone and use similar body language, you will become a people magnet
2. Become a better listener - Listen first. Rather than fighting for ear space allow your colleagues to finish speaking before butting in. You will be known as a really good conversationalist.
3. Ask good questions - Ask open questions and allow your colleague to fully answer. The more that you can get the other person to talk the more they will like being with you.

ONE of my Successes was being selected as "A Women in Physics" for this APS Publication.



American Physics Society

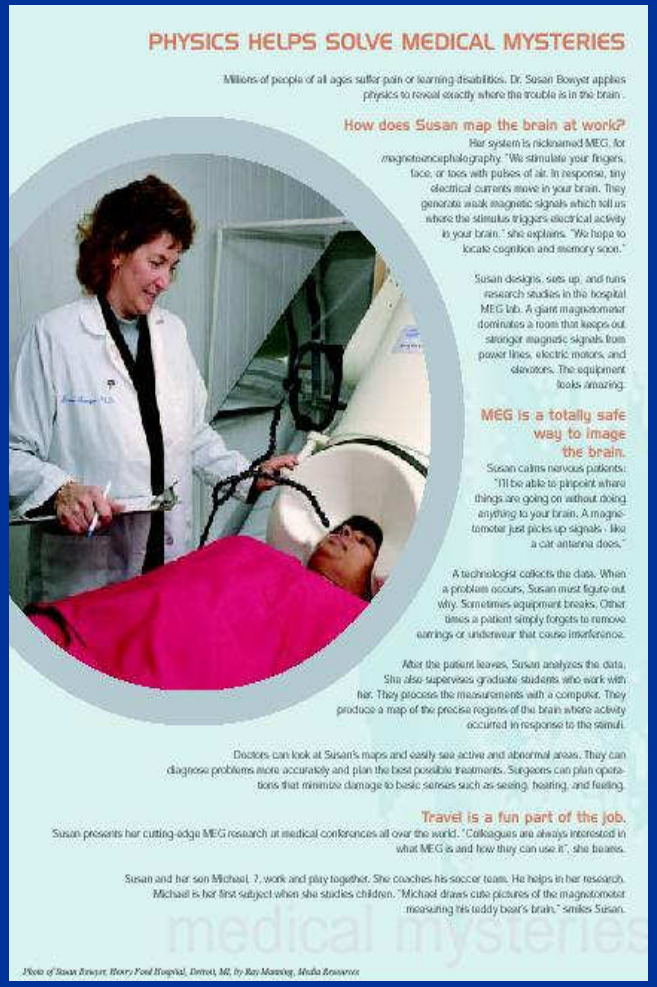
www.APS.org

Physics in your Future

Investigate the mysteries of the brain

Share the excitement of Science

Give presentations around the world on cutting edge translational research



PHYSICS HELPS SOLVE MEDICAL MYSTERIES

Millions of people of all ages suffer pain or learning disabilities. Dr. Susan Bowyer applies physics to reveal exactly where the trouble is in the brain.

How does Susan map the brain at work?

Her system is nicknamed MEG, for magnetoencephalography. "We stimulate your fingers, face, or toes with pulses of air. In response, tiny electrical currents move in your brain. They generate weak magnetic signals which tell us where the stimulus triggers electrical activity in your brain," she explains. "We hope to locate cognition and memory soon."

Susan designs, sets up, and runs research studies in the hospital MEG lab. A giant magnetometer dominates a room that keeps out stronger magnetic signals from power lines, electric motors, and elevators. The equipment looks amazing.

MEG is a totally safe way to image the brain.

Susan calms nervous patients: "I'll be able to pinpoint where things are going on without doing anything to your brain. A magnetometer just picks up signals - like a car antenna does."

A technologist collects the data. When a problem occurs, Susan must figure out why. Sometimes equipment breaks. Other times a patient simply forgets to remove earrings or underwear that cause interference.

After the patient leaves, Susan analyzes the data. She also supervises graduate students who work with her. They process the measurements with a computer. They produce a map of the precise regions of the brain where activity occurred in response to the stimuli.

Doctors can look at Susan's maps and easily see active and abnormal areas. They can diagnose problems more accurately and plan the best possible treatments. Surgeons can plan operations that minimize damage to basic senses such as seeing, hearing, and feeling.

Travel is a fun part of the job.

Susan presents her cutting-edge MEG research at medical conferences all over the world. "Colleagues are always interested in what MEG is and how they can use it", she beams.

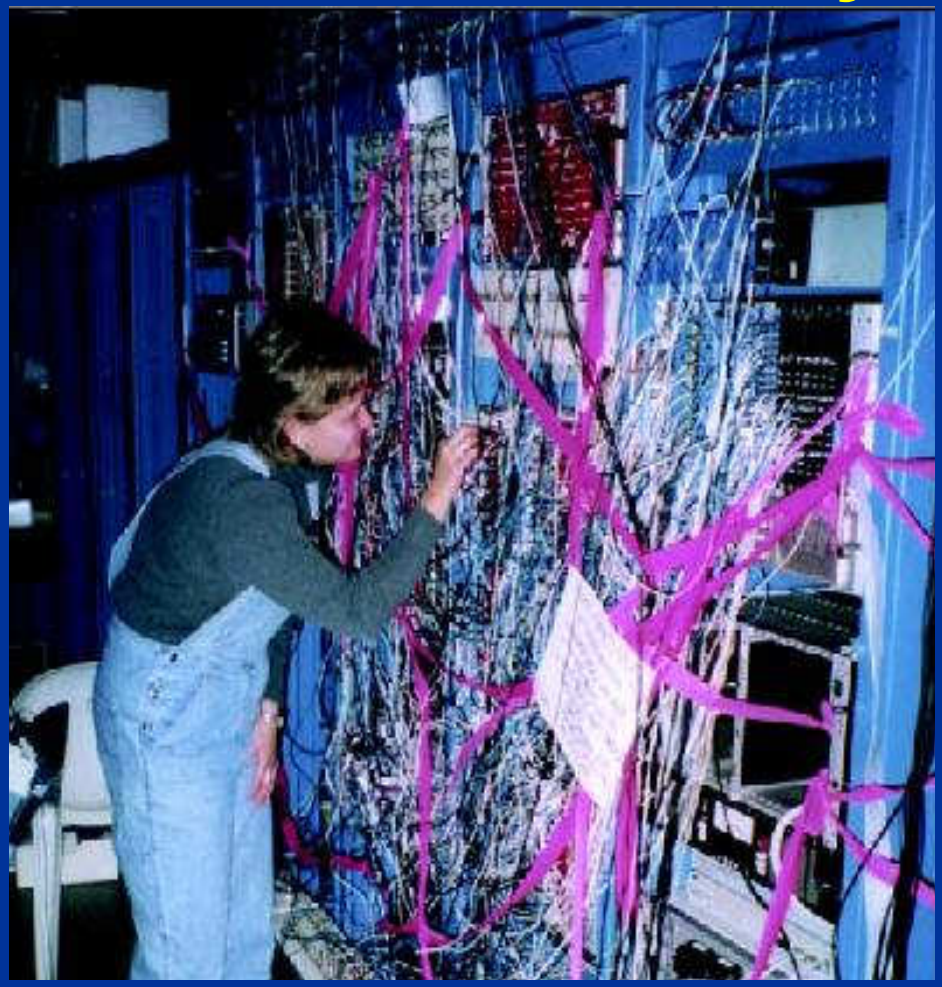
Susan and her son Michael, 7, work and play together. She coaches his soccer team. He helps in her research. Michael is her first subject when she studies children. "Michael draws cute pictures of the magnetometer measuring his teddy bear's brain," smiles Susan.

medical mysteries

Photo of Susan Bowyer, Henry Ford Hospital, Detroit, MI, by Ray Manning, Media Resources

APS.org

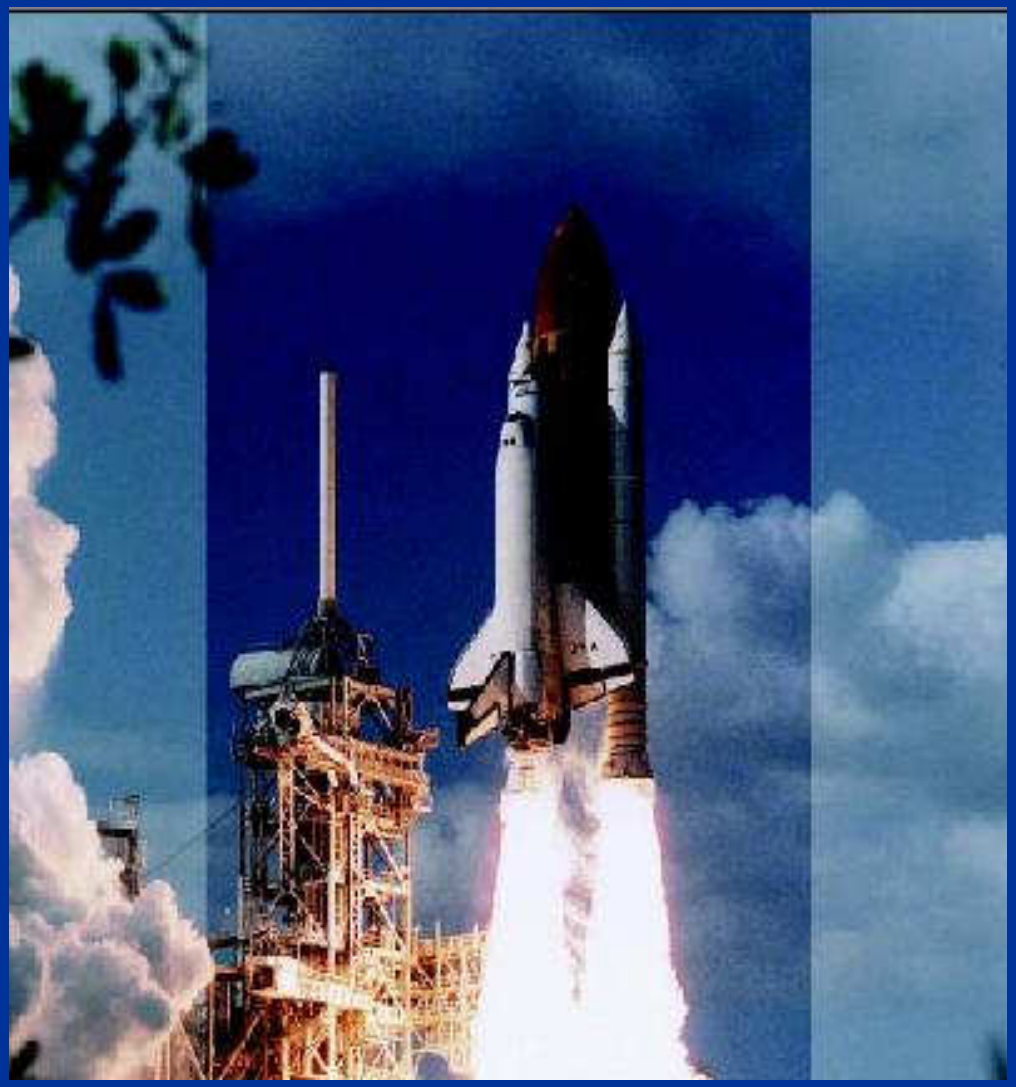
Invest in your Future



Math and science are demanding. They require solving problems and doing laboratory experiments. Think of the effort and time you spend as an investment in your future. Your rewards will be new skills, self-confidence, friends, and career possibilities.

APS.org

Choosing your career



Choosing a career is a big decision. Most people work as long as 50 years. It's very important to find work that you'll enjoy. You'll have a great selection of rewarding careers to choose from if you study math and science.

APS.org

Conclusions

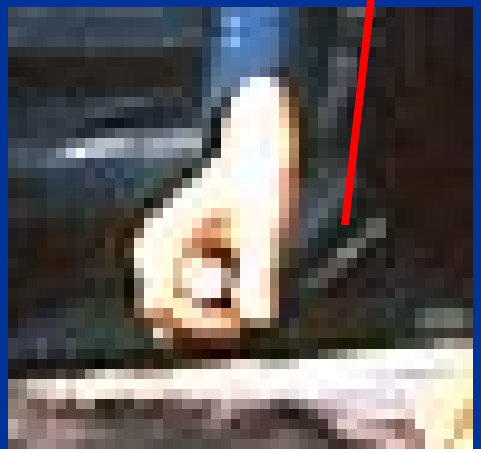
- Physics is an exciting career!!!
- Lots of job opportunities.
- Rewarding experiences.

REMEMBER

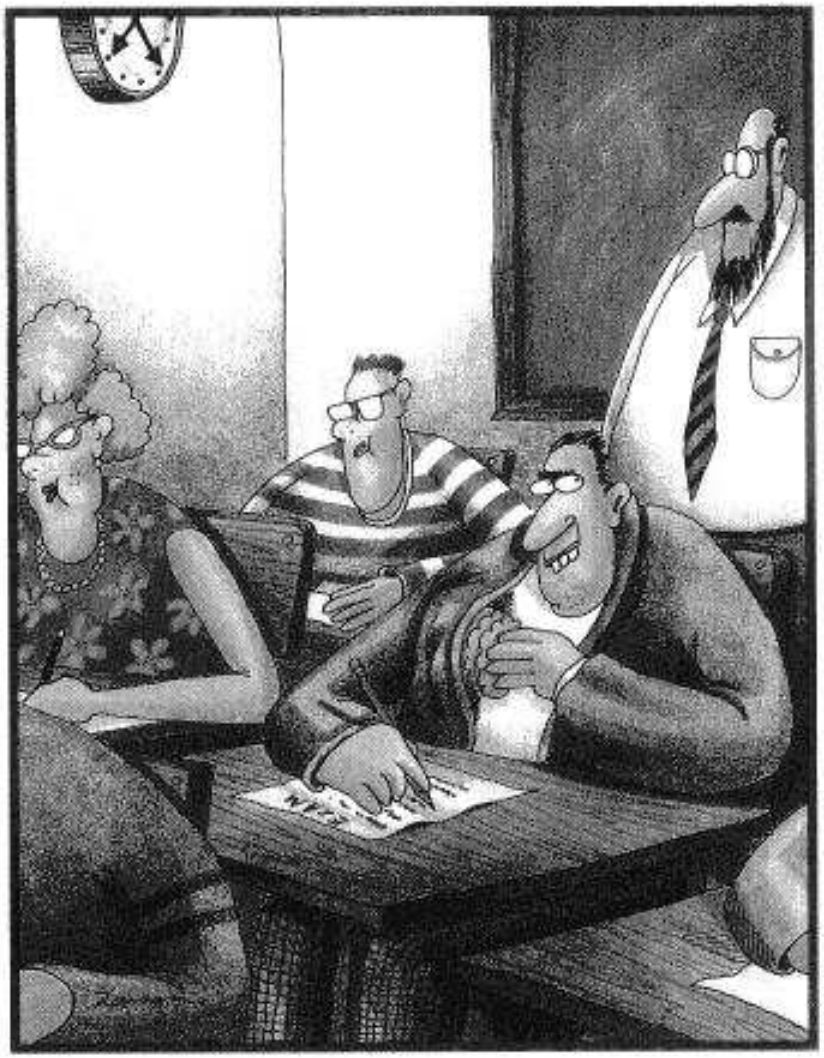
- **Keep your brain Safe**
  Say NO to Drugs.

- **Avoid head injury**
  Always wear your helmet.

The Future



THE FAR SIDE® By GARY LARSON



Midway through the exam, Allen pulls out a bigger brain.