# Brain Facts and Figures

These data were obtained from several textbooks. All numbers are for humans unless otherwise indicated.

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## Brain

| Average Brain Weights (in grams) | | | | |
|---|---|---|---|---|
| **Species** | **Weight (g)** | | **Species** | **Weight (g)** |
| adult human | 1,300 - 1,400 | | newborn human | 350 - 400 |
| sperm whale | 7,800 | | fin whale | 6,930 |
| elephant | 4,783 | | humpback whale | 4,675 |
| gray whale | 4,317 | | killer whale | 5,620 |
| bowhead whale | 2,738 | | pilot whale | 2,670 |
| bottle-nosed dolphin | 1,500 - 1,600 | | walrus | 1,020 - 1,126 |
| Pithecanthropus Man | 850 - 1,000 | | camel | 762 |
| giraffe | 680 | | hippopotamus | 582 |

| | | | | |
|---|---|---|---|---|
| leopard seal | 542 | | horse | 532 |
| polar bear | 498 | | gorilla | 465 - 540 |
| cow | 425-458 | | chimpanzee | 420 |
| orangutan | 370 | | California sea lion | 363 |
| manatee | 360 | | tiger | 263.5 |
| lion | 240 | | grizzly bear | 234 |
| pig | 180 | | jaguar | 157 |
| sheep | 140 | | baboon | 137 |
| rhesus monkey | 90-97 | | dog (beagle) | 72 |
| aardvark | 72 | | beaver | 45 |
| shark (great white) | 34 | | shark (nurse) | 32 |
| cat | 30 | | porcupine | 25 |
| squirrel monkey | 22 | | marmot | 17 |
| rabbit | 10-13 | | platypus | 9 |
| alligator | 8.4 | | squirrel | 7.6 |
| opossum | 6 | | flying lemur | 6 |
| fairy anteater | 4.4 | | guinea pig | 4 |
| ring-necked pheasant | 4.0 | | hedgehog | 3.35 |
| tree shrew | 3 | | fairy armadillo | 2.5 |
| owl | 2.2 | | grey partridge | 1.9 |
| rat (400 g body weight) | 2 | | hamster | 1.4 |
| elephant shrew | 1.3 | | house sparrow | 1.0 |
| european quail | 0.9 | | turtle | 0.3-0.7 |
| bull frog | 0.24 | | viper | 0.1 |
| goldfish | 0.097 | | green lizard | 0.08 |

Reference for many of these brain weights:


1. Blinkov, S.M. and Glezer, I.I. *The Human Brain in Figures and Tables*. A Quantitative Handbook, New York: Plenum Press, 1968.
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3. Nieuwenhuys, R., Ten Donkelaar, H.J. and Nicholson, C. *The Central Nervous System of Vertebrates. Vol. 3*, Berlin: Springer, 1998.
4. Berta, A., et al. *Marine Mammals. Evolutionary Biology*, San Diego: Academic Press, 1999.
5. Mink, J.W., Blumenschine, R.J. and Adams, D.B. Ratio of central nervous system to

body metabolism in vertebrates: its constancy and functional basis. *Am. J. Physiology*, 241:R203-R212, 1981.
6. Rehkamper, G., Frahm, H.D. and Zilles, K. Quantitative development of brain and brain structures in birds (Galliformes and Passeriformes) compared to that in mammals (Insectivores and Primates). *Brain Beh. Evol.*, 37:125-143, 1991.
7. Ridgway, S.H. and Harrison, S., *Handbook of Marine Mammals, Vol. 3*, London: Academic Press, 1985.
8. Shoshani, J., Kupsky, W.J. and Marchant, G.H., Elephant brain. Part I: Gross morphology functions, comparative anatomy, and evolution, *Brain Res. Bulletin*, 70:124-157, 2006.

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% brain of total body weight (150 pound human) = 2%
Average brain width = 140 mm
Average brain length = 167 mm
Average brain height = 93 mm

Intracranial contents by volume (1,700 ml, 100%): brain = 1,400 ml (80%); blood = 150 ml (10%); cerebrospinal fluid = 150 ml (10%) (from Rengachary, S.S. and Ellenbogen, R.G., editors, *Principles of Neurosurgery*, Edinburgh: Elsevier Mosby, 2005)

Average number of neurons in the brain = 100 billion
Number of neurons in *octopus* brain = 300 million (from *How Animals See*, S. Sinclair, 1985)
Number of neurons in *honey bee* brain = 950,000 (from Menzel, R. and Giurfa, M., Cognitive architecture of a mini-brain: the honeybee, *Trd. Cog. Sci.*, 5:62-71, 2001.)
Number of neurons in *Aplysia* nervous system = 18,000-20,000
Number of neurons in each segmental ganglia in the *leech* = 350
Volume of the brain of a locust = $6mm^3$ (from *The Neurobiology of the Insect Brain*, Burrows, M., 1996)

Ratio of the volume of grey matter to white matter in the cerebral hemipheres (20 yrs. old) = 1.3 (Miller, A.K., Alston, R.L. and Corsellis, J.A., Variation with age in the volumes of grey and white matter in the cerebral hemispheres of man: measurements with an image analyser, *Neuropathol Appl Neurobiol.*, 6:119-132, 1980)
Ratio of the volume of grey matter to white matter in the cerebral hemipheres (50 yrs. old) = 1.1 (Miller et al., 1980)
Ratio of the volume of grey matter to white matter in the cerebral hemipheres (100 yrs. old) = 1.5 (Miller et al., 1980)
% of cerebral oxygen consumption by white matter = 6%
% of cerebral oxygen consumption by gray matter = 94%

Average number of glial cells in brain = 10-50 times the number of neurons (New research suggests the neuron-to-glia ratio may be much smaller, closer to 1:1)

(For more information about the number of neurons in the brain, see R.W. Williams and K. Herrup, *Ann. Review Neuroscience*, 11:423-453, 1988)

Number of neocortical neurons (females) = 19.3 billion (Pakkenberg, B., Pelvig, D., Marner,L., Bundgaard, M.J., Gundersen, H.J.G., Nyengaard, J.R. and Regeur, L. Aging and the human neocortex. Exp. Gerontology, 38:95-99, 2003 and Pakkenberg, B. and Gundersen, H.J.G. Neocortical neuron number in humans: effect of sex and age. J. Comp. Neurology, 384:312-320, 1997.)
Number of neocortical neurons (males) = 22.8 billion (Pakkenberg et al., 1997; 2003)

Average loss of neocortical neurons = 85,000 per day (~31 million per year) (Pakkenberg et al., 1997; 2003)
Average loss of neocortical neurons = 1 per second (Pakkenberg et al., 1997; 2003)
Average number of neocortical glial cells (young adults ) = 39 billion (Pakkenberg et al., 1997; 2003)
Average number of neocortical glial cells (older adults) =36 billion (Pakkenberg et al., 1997; 2003)
Number of neurons in cerebral cortex (rat) = 21 million (Korbo, L., et al., *J. Neurosci Methods,* 31:93-100, 1990)
Length of myelinated nerve fibers in brain = 150,000-180,000 km (Pakkenberg et al., 1997; 2003)
Number of synapses in cortex = 0.15 quadrillion (Pakkenberg et al., 1997; 2003)
Difference number of neurons in the right and left hemispheres = 186 million MORE neurons on left side than right side (Pakkenberg et al., 1997; 2003)

| | Proportion by Volume (%) | |
|---|---|---|
| | Rat | Human |
| Cerebral Cortex | 31 | 77 |
| Diencephalon | 7 | 4 |
| Midbrain | 6 | 4 |
| Hindbrain | 7 | 2 |
| Cerebellum | 10 | 10 |
| Spinal Cord | 35 | 2 |
| (Reference: *Trends in Neurosciences*, 18:471-474, 1995) | | |

| Composition of Brain and Muscle | | |
|---|---|---|
| | Skeletal Muscle (%) | Whole Brain (%) |
| Water | 75 | 77 to 78 |
| Lipids | 5 | 10 to 12 |
| Protein | 18 to 20 | 8 |
| Carbohydrate | 1 | 1 |
| Soluble organic substances | 3 to 5 | 2 |
| Inorganic salts | 1 | 1 |
| (Reference: McIlwain, H. and Bachelard, H.S., *Biochemistry and the Central Nervous System*, Edinburgh: Churchill Livingstone, 1985) | | |

Total surface area of the cerebral cortex = 2,500 $cm^2$ (2.5 $ft^2$; A. Peters, and E.G. Jones, *Cerebral Cortex*, 1984)

Total surface area of the cerebral cortex (lesser shrew) = 0.8 $cm^2$
Total surface area of the cerebral cortex (rat) = 6 $cm^2$
Total surface area of the cerebral cortex (cat) = 83 $cm^2$
Total surface area of the cerebral cortex (African elephant) = 6,300 $cm^2$
Total surface area of the cerebral cortex (Bottlenosed dolphin) = 3,745 $cm^2$ (S.H. Ridgway, *The Cetacean Central Nervous System*, p. 221)

Total surface area of the cerebral cortex (pilot whale) = 5,800 $cm^2$

Total surface area of the cerebral cortex (false killer whale) = 7,400 $cm^2$

(Reference for surface area figures: Nieuwenhuys, R., Ten Donkelaar, H.J. and Nicholson, C., *The Central nervous System of Vertebrates, Vol. 3*, Berlin: Springer, 1998)

Total number of neurons in cerebral cortex = 10 billion (from G.M. Shepherd, *The Synaptic Organization of the Brain*, 1998, p. 6). However, C. Koch lists the total number of neurons in the cerebral cortex at 20 billion (*Biophysics of Computation. Information Processing in Single Neurons*, New York: Oxford Univ. Press, 1999, page 87).

Total number of synapses in cerebral cortex = 60 trillion (yes, trillion) (from G.M. Shepherd, *The Synaptic Organization of the Brain*, 1998, p. 6). However, C. Koch lists the total synapses in the cerebral cortex at 240 trillion (*Biophysics of Computation. Information Processing in Single Neurons*, New York: Oxford Univ. Press, 1999, page 87).

Percentage of total cerebral cortex volume (human): frontal lobe = 41%; temporal lobe = 22%; parietal lobe = 19%; occipital lobe = 18%. (Caviness Jr., et al. *Cerebral Cortex*, 8:372-384, 1998.)

Number of cortical layers = 6

Thickness of cerebral cortex = 1.5-4.5 mm

Thickness of cerebral cortex (Bottlenosed dolphin) = 1.3-1.8 mm (S.H. Ridgway, *The Cetacean Central Nervous System*, p. 221)

EEG - beta wave frequency = 13 to 30 Hz

EEG - alpha wave frequency = 8 to 13 Hz

EEG - theta wave frequency = 4 to 7 Hz

EEG - delta wave frequency = 0.5 to 4 Hz

World record, time without sleep = 264 hours (11 days) by Randy Gardner in 1965. Note: In *Biopsychology* (by J.P.J. Pinel, Boston: Allyn and Bacon, 2000, p. 322), the record for time awake is attributed to Mrs. Maureen Weston. She apparently spent 449 hours [18 days, 17 hours] awake in a rocking chair. The *Guinness Book of World Records* [1990] has the record belonging to Robert McDonald who spent 453 hours, 40 min in a rocking chair.

Time until unconsciousness after loss of blood supply to brain = 8-10 sec

Time until reflex loss after loss of blood supply to brain = 40-110 sec

Rate of neuron growth (early pregnancy) = 250,000 neurons/minute

Length of spiny terminals of a Purkinje cell = 40,700 micron

Number spines on a Purkinje cell dendritic branchlet = 61,000

Surface area of cerebellar cortex = 50,000 $cm^2$ (from G.M. Shepherd, *The Synaptic Organization of the Brain*, 1998, p. 255)

Weight of adult cerebellum = 150 grams (Afifi, A.K. and Bergman, R.A., *Functional Neuroanatomy*, New York: McGraw-Hill, 1998)

Number of Purkinje cells = 15-26 million

Number of synapses made on a Purkinje cell = up to 200,000

Weight of hypothalamus = 4 g

Volume of suprachiasmatic nucleus = 0.3 $mm^3$

Number of fibers in pyramidal tract above decussation = 1,100,000

Number of fibers in corpus callosum = 250,000,000

Area of the corpus callosum (midsagittal section) = 6.2 $cm^2$

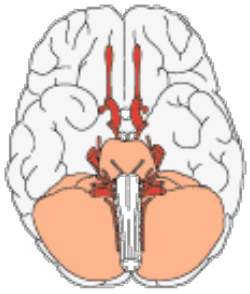
| Species | **Cerebellum** Weight (grams) | Body Weight (grams) |
|---|---|---|
| Mouse | 0.09 | 58 |
| Bat | 0.09 | 30 |

| | | |
|---|---|---|
| Flying Fox | 0.3 | 130 |
| Pigeon | 0.4 | 500 |
| Guinea Pig | 0.9 | 485 |
| Squirrel | 1.5 | 350 |
| Chinchilla | 1.7 | 500 |
| Rabbit | 1.9 | 1,800 |
| Hare | 2.3 | 3,000 |
| Cat | 5.3 | 3,500 |
| Dog | 6.0 | 3,500 |
| Macaque | 7.8 | 6,000 |
| Sheep | 21.5 | 25,000 |
| Bovine | 35.7 | 300,000 |
| Human | 142 | 60,000 |
| Source: Sultan, F. and Braitenberg, V. Shapes and sizes of different mammalian cerebella. A study in quantitative comparative neuroanatomy. *J. Hirnforsch.*, 34:79-92, 1993. | | |

Total volume of cerebrospinal fluid (adult) = 125-150 ml
Total volume of cerebrospinal fluid (infant) = 50 ml (Source: Aghababian, R., *Essentials of Emergency Medicine*, 2006)
Turnover of entire volume of cerebrospinal fluid = 3 to 4 times per day (from Kandel et al., 2000, p. 1296)
Rate of production of CSF = 0.35 ml/min (500 ml/day) (from Kandel et al., 2000, p. 1296)
pH of cerebrospinal fluid = 7.33 (from Kandel et al., 2000, p. 1296)
Specific gravity of cerebrospinal fluid = 1.007
Color of normal CSF = clear and colorless
White blood cell count in CSF = 0-3 per $mm^3$
Red blood cell count in CSF = 0-5 per $mm^3$
Normal intracranial pressure = 150 - 180 mm of water

| Composition of Serum and Cerebrospinal Fluid (CSF) | | |
|---|---|---|
| | CSF | Serum |
| Water (%) | 99 | 93 |
| Protein (mg/dl) | 35 | 7000 |
| Glucose (mg/dl) | 60 | 90 |
| Osmolarity (mOsm/l) | 295 | 295 |
| Na (meq/l) | 138 | 138 |
| K (meq/l) | 2.8 | 4.5 |
| Ca (meq/l) | 2.1 | 4.8 |
| Mg (meq/l) | 0.3 | 1.7 |
| Cl (meq/l) | 119 | 102 |

| | | |
|---|---|---|
| pH | 7.33 | 7.41 |
| (Reference: Fishman, R.A. Cerebrospinal Fluid in Disease of the Nervous System. Philadelphia: Saunders, 1980) | | |



Number of cranial nerves = 12

I- olfactory

II- optic

Number of fibers in human optic nerve = 1,200,000
Number of fibers in cat optic nerve = 119,000
Number of fibers in albino rat optic nerve = 74,800
Length of optic nerve = 50 mm (Reference: Kanski, J.J., *Clinical Ophthalmology*, 6th ed., Edinburgh: Elsevier, 2007.)

III- oculomotor

Number of fibers in oculomotor nerve = 25,000-35,000

IV- trochlear

Number of fibers in trochlear nerve = 2,000-3,500
Number of neurons in nucleus of the trochlear nerve = 2,000-3,500

V- trigeminal

Number of fibers in motor root of trigeminal nerve = 8,100
Number of fibers in sensory root of trigeminal nerve = 140,000

VI- abducens

Number of fibers in abducens nerve (at exit from brain stem) = 3,700

VII- facial

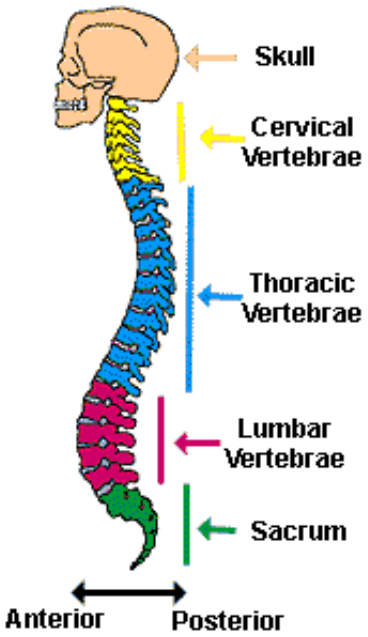
Number of fibers in facial nerve (at exit from brain stem) = 9,000-10,000
Length of nucleus of the facial nerve = 2 to 5.6 mm
Number of neurons in nucleus of the facial nerve = 7,000

VIII-vestibulocochlear
IX- glossopharyngeal
X- vagus

Length of dorsal motor nucleus of the vagus nerve = 10 mm

XI- spinal accessory
XII- hypoglossal

Number of neurons in nucleus of the hypoglossal nerve = 4,500-7,500
Length of nucleus of the hypoglossal nerve = 10 mm




# Spinal Cord

Number of neurons in human spinal cord = 1 billion (from Kalat, J.W., *Biological Psychology*, 6th Edition, 1998, page 24)
Length of human spinal cord = 45 cm (male); 43 cm (female)
Length of human vertebral column (male) = 71 cm
Length of human vertebral column (female) = 61 cm
Length of cat spinal cord = 34 cm
Length of rabbit spinal cord = 18 cm
Length of the filum terminale = 15 cm

Cross sectional area of the spinal cord (C2 level) = 110 $mm^2$
Cross sectional area of the spinal cord (C4 level) = 122 $mm^2$
Cross sectional area of the spinal cord (C5 level) = 78 $mm^2$
Cross sectional area of the spinal cord (C7 level) = 85 $mm^2$
(Reference: Watson, C., Paxinos, G. and Kayalioglu, G., *The Spinal Cord*, Amsterdam: Elsevier, 2009)

Weight of human spinal cord = 35 g
Weight of rabbit spinal cord = 4 g
Weight of rat spinal cord (400 g body weight) = 0.7 g
Maximal circumference of cervical enlargement = 38 mm
Maximal circumference of lumbar enlargement = 35 mm
Pairs of Spinal Nerves = 31
Number of spinal cord segments (human)= 31

- 8 cervical segments
- 12 thoracic segments
- 5 lumbar segments
- 5 sacral segments
- 1 coccygeal segment

Number of Spinal Cord segments (rat)= 34

- 8 cervical segments
- 13 thoracic segments
- 6 lumbar segments
- 4 sacral segments
- 3 coccygeal segments

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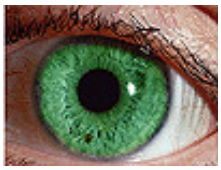

# Sensory Apparatus

**Audition**

Surface area of the tympanic membrane = 85$mm^2$ (*Hearing: Its Physiology and Pathophysiology*, A.R. Moller, Amsterdam: Elsevier, 2006)
Length of the eustachian tube = 3.5 to 3.9 cm (*Hearing. Its Physiology and Pathophysiology*, A.R. Moller, San Diego, Academic Press, 2000.)
Number of hair cells in cochlea = 3,500 inner hair cells; 12,000 outer hair cells (*Hearing. Its Physiology and*

*Pathophysiology*, A.R. Moller, San Diego, Academic Press, 2000.)
Number of fibers in auditory nerve = 30,000 (*Hearing: Its Physiology and Pathophysiology*, A.R. Moller, Amsterdam: Elsevier, 2006)
Length of auditory nerve = 2.5 cm (*Hearing: Its Physiology and Pathophysiology*, A.R. Moller, Amsterdam: Elsevier, 2006)
Number of neurons in cochlear nuclei = 8,800 (Northern, J.L. and Downs, M.P., Hearing in Children, 5th edition, Philadelphia: Lippincott Williams & Wilkins, 2002.)
Number of neurons in inferior colliculus = 392,000 (Northern, J.L. and Downs, M.P., Hearing in Children, 5th edition, Philadelphia: Lippincott Williams & Wilkins, 2002.)
Number of neurons in medial geniculate body = 570,000
Number of neurons in auditory cortex = 100,000,000
Hearing Range (young adult human) = 20 to 20,000 Hz
Hearing Range (elderly human) = 50 to 8,000 Hz (Guyton, A.C., *Textbook of Medical Physiology*, 1986)
Hearing Range (rat) = 1,000 to 50,000 Hz
Hearing Range (cat) = 100 to 60,000 Hz
Hearing Range (dolphin) = 200 to 150,000 Hz
Hearing Range (elephant) = 1 to 20,000 Hz
Hearing Range (goldfish) = 5 to 2,000 Hz
Hearing Range (moth, noctuid) = 1,000 to 240,000 Hz
Hearing Range (mouse) = 1,000 to 100,000 Hz
Hearing Range (sea lion) = 100 to 40,000 Hz
(Hearing range reference: *Discover Science Almanac*, New York: Hyperion, 2003)
Most sensitive range of human hearing = 1,000-4,000 Hz
Length of external auditory meatus (ear canal) = 2.7 cm

Diameter of external auditory meatus (ear canal)= 0.7 cm
Weight of malleus = 23 mg; length of malleus = 8-9 mm
Weight of incus = 30 mg; dimensions of incus = 5 mm by 7 mm
Weight of stapes = 3-4 mg; dimensions of stapes = 3.5 mm high, 3 mm long, 1.4 mm wide
Malleus, incus and stapes references: Gelfand, S.A. *Hearing: An Introduction to Psychological and Physiological Acoustics*, 4th edition, New York: Marcel Dekker, 2004.

Length of cochlea = 35 mm
Width of cochlea = 10 mm
Number of turns in the cochlea = 2.2-2.9
Length of basilar membrane = 25-35 mm
Width of basilar membrane = 150 microns (at base of cochlea) (*Hearing. Its Physiology and Pathophysiology*, A.R. Moller, San Diego, Academic Press, 2000.)
Auditory Pain Threshold = 130 db
Threshold for hearing damage = 90 db for an extended period of time

| Decibel Sound Scale | |
|---|---|
| Decibels | Sound |
| 180 | Rocket launching pad |
| 140 | Jet plane |
| 140 | Gunshot blast |
| 120 | Automobile horn |
| 130 | Pain threshold |
| 120 | Discomfort |

| | |
|---|---|
| 90 | Subway |
| 80 | Noisy Restaurant |
| 75 | Busy traffic |
| 66 | Normal conversation |
| 50 | Average home |
| 30 | Soft whisper |
| Source: Lee, K.J., *Essential Otolaryngology*, 8th edition, New York: McGraw-Hill, 2003. | |

**Taste**

Total number of human taste buds (tongue, palate, cheeks) = 10,000
Number of taste buds on the tongue = 9,000
Height of taste bud = 50-100 microns (From: Farbman, A.I., Taste Bud, in G. Adelman, eds., *Encyclopedia of Neuroscience*, 1987)
Diameter of taste bud = 30-60 microns (From: Farbman, A.I.)
Number of receptors on each taste bud = 50-150 (Boron, W.F. and Boulpaep, E.L., *Medical Physiology. A Cellular and Molecular Approach*, Philadelphia: Saunders, 2003)
Diameter of taste receptor = 10 micron
Diameter of taste fiber = less than 4 micron
Taste threshold for quinine sulfate = 3.376 mg/liter water

**Smell**

Number of **human** olfactory receptor cells = 12 million (Shier, D., Butler, J. and Lewis, R. *Hole's Human Anatomy & Physiology*, Boston: McGraw Hill, 2004)
Number of **rabbit** olfactory receptor cells = 100 million
Number of **dog** olfactory receptor cells = 1 billion
Number of **bloodhound** olfactory receptor cells = 4 billion (Shier, D., Butler, J. and Lewis, R. *Hole's Human Anatomy & Physiology*, Boston: McGraw Hill, 2004)
Surface area of olfactory epithelium (contains olfactory receptor cells) in humans = 10 $cm^2$ (Bear, M.F., Connors, B.W. and Pradiso, M.A., Neuroscience: Exploring the Brain, 2nd edition, Baltimore: Lippincott Williams and Wilkins, 2001, p. 269)
Surface area of bloodhound olfactory epithelium = 59 $in^2$ (Shier, D., Butler, J. and Lewis, R. *Hole's Human Anatomy & Physiology*, Boston: McGraw Hill, 2004)
Area of olfactory epithelium in some dogs = 170 $cm^2$ (Bear, M.F., Connors, B.W. and Pradiso, M.A., Neuroscience: Exploring the Brain, 2nd edition, Baltimore: Lippincott Williams and Wilkins, 2001, p. 269)
Area of olfactory epithelium in cats = 21 $cm^2$ (Bradshaw, J., Behavioral biology, in *The Waltham Book of Dog and Cat Behaviour*, ed. C. Thorne, Oxford: Pergamon Press, 1992)
Thickness of olfactory epithelium mucous layer = 20-50 microns. (Boron and Boulpaep, 2003)
Diameter of olfactory receptor axons = 0.1-0.2 micron
Diameter of distal end olfactory receptor cell = 1 micron
Diameter of olfactory receptor cell = 40-50 micron
Number of cilia per olfactory receptor cell = 10-30
Length of cilia on olfactory receptor cell = 100-150 micron
Concentration for detection threshold of musk = 0.00004 mg/liter air

## Vision

Length of eyeball (adult) = 24.2 mm (from Riordan-Eva, P. and Whitcher, J.P., *Vaughan & Asbury's General Ophthalmology*, 17th ed., New York: Lange Medical Books, 2008)
Length of eyeball (newborn) = 16.5 mm (from Riordan-Eva and Whitcher, 2008)
Volume of eyeball = 5.5 $cm^3$
Weight of eyeball = 7.5 g
Average time between blinks = 2.8 seconds
Average duration of a single blink = 0.1-0.4 seconds (Schiffman, H.R., *Sensation and Perception. An Integrated Approach*, New York: John Wiley and Sons, Inc., 2001)
Thickness of cornea = ~0.5 mm in center; ~1 mm in periphery (Foster, C.S., Azar, D.T. and Dohlman, C.H. *Smolin and Thoft's The Cornea. Scientific Foundations and Clinical Practice, 4th edition,* Philadelphia: Lippincott Williams & Wilkins, 2005)
Diameter of cornea = 11.5 mm
Thickness of lens = 4 mm (from Riordan-Eva and Whitcher, 2008)
Diameter of lens = 9 mm (from Riordan-Eva and Whitcher, 2008)
Composition of lens = 65% water; 35% protein (from Riordan-Eva and Whitcher, 2008)
Nerves in lens = 0 (from Riordan-Eva and Whitcher, 2008)
Blood vessels in lens = 0 (from Riordan-Eva and Whitcher, 2008)
Number of retinal receptor cells = 5-6 million cones; 120-140 million rods
Number of retinal ganglion cells = 800 thousand to 1 million
Number of fibers in optic nerve = 1,200,000
Number of neurons in lateral geniculate body = 570,000
Number of cells in visual cortex (area 17) = 538,000,000
Wavelength of visible light (human) = 400-700 nm
Amount of light necessary to excite a rod = 1 photon
Amount of light necessary to excite a cone = 100 photons
Location of the greatest density of rods = $20^o$ from fovea
Highest density of rods = 160,000 per $mm^2$
Peak density of rods (cat) = 400,000 per $mm^2$
Density of cones in fovea = 200,000 per $mm^2$
Diameter of fovea = 1.5 mm
Intraocular pressure = 10-20 mm Hg
Volume of orbit = 30 ml
Area of retina = 2,500 $mm^2$
Thickness of retina = 120 microns (ranges from 100 to 230 microns)
Production rate of aqueous humor = 2 microliters/min
Turnover of aqueous humor = 15 times/day
% volume of eye occupied by the vitreous = 80%
Maximal sensitivity of red cones = 570 nm
Maximal sensitivity of green cones = 540 nm
Maximal sensitivity of blue cones = 440 nm
More Facts and Figures about the Human Retina from WebVision.

## Touch

Weight of skin (adult human) = 9 lb.(4.1 kg) (Source: Schiffman, H.R., *Sensation and Perception. An Integrated Approach*, New York: John Wiley and Sons, Inc., 2001)
Surface area of skin (adult human) = 3,000 $in^2$ (~1.8 $m^2$) (Source: Schiffman, H.R., *Sensation and Perception. An Integrated Approach*, New York: John Wiley and Sons, Inc., 2001)

Number of tactile receptors in the hand = 17,000
Number of nerve endings in hand = 1,300 per $in^2$
von Frey threshold (Face) = 5 mg
2 point threshold (Finger) = 2-3 mm
Length of Meissner corpuscle = 90 - 120 micron
Density of receptors on finger tips = 2,500 per $cm^2$
Density of Meissner's corpuscles on finger tips = 1,500 per $cm^2$
Density of Merkel's cells on finger tips = 750 per $cm^2$
Density of Pacinian corpuscles on finger tips = 75 per $cm^2$
Density of Ruffini's corpuscles on finger tips = 75 per $cm^2$
Thermal pain threshold = 45°C

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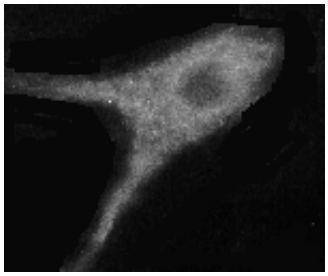

# Neurons

Mass of a large sensory neuron = $10^{-6}$gram (from Groves and Rebec, *Introduction to Biological Psychology*, 3rd edition, Dubuque: Wm.C. Brown Publ., 1988)
Number of synapses for a "typical" neuron = 1,000 to 10,000
Diameter of neuron = 4 micron (granule cell) to 100 micron (motor neuron in cord)
Diameter of neuron nucleus = 3 to 18 micron
Length of Giraffe primary afferent axon (from toe to neck) = 15 feet
Resting potential of squid giant axon = -70 mV
Conduction velocity of action potential = 0.6-120 m/s (1.2-250 miles/hr)

Single sodium pump maximum transport rate = 200 Na ions/sec; 130 K ions/sec
Typical number of sodium pumps = 1000 pumps/$micron^2$ of membrane surface (from Willis and Grossman, *Medical Neurobiology*, Mosby, St. Louis, 1981, p. 36)
Total number of sodium pumps for a small neuron = 1 million
Density of sodium channels (squid giant axon) = 300 per $micron^2$ (from Hille, B., *Ionic Channels of Excitable Membranes*, Sinauer, Sunderland, 1984, p. 210.)
Number of voltage-gated sodium channels at each node = 1,000 to 2,000 per $micron^2$ (from Nolte, J., *The Human Brain*, Mosby, 1999, p. 163.)
Number of voltage-gated sodium channels between nodes = 25 per $micron^2$ (from Nolte, J., *The Human Brain*, Mosby, 1999, p. 163.)
Number of voltage-gated sodium channels in unmyelinated axon = 100 to 200 per $micron^2$ (from Nolte, J., *The Human Brain*, Mosby, 1999, p. 163.)
Diameter of microtubule = 20 nanometer
Diameter of microfilament = 5 nanometer
Diameter of neurofilament = 10 nanometer
Thickness of neuronal membrane = 5 nanometer
Thickness of squid giant axon membrane = 50-100 A
Membrane surface area of a typical neuron = 250,000 $um^2$ (Bear et al., 2001)
Membrane surface area of 100 billion neurons = 25,000 $m^2$, the size of four soccer fields (Bear, M.F., Connors, B.W. and Pradiso, M.A., Neuroscience: Exploring the Brain, 2nd edition, Baltimore: Lippincott Williams and Wilkins, 2001, p. 97)

Typical synaptic cleft distance = 20-40 nanometers across (from Kandel et al., 2000, p. 176)
% neurons stained by the Golgi method = 5%

Slow axoplasmic transport rate = 0.2-4 mm/day (actin, tubulin)
Intermediate axoplasmic transport rate = 15-50 mm/day (mitochondrial protein)
Fast axoplasmic transport rate = 200-400 mm/day (peptides, glyolipids)
Number of molecules of neurotransmitter in one synaptic vesicle = 5,000 (from Kandel et al., 2000, p. 277)
Diameter of synaptic vesicle = 50 nanometer (small); 70-200 nanometer (large)
Diameter of neurofilament = 7 - 10 nm
Diameter of microtubule = 25 nm
Internodal Length = 150 - 1500 microns (depends on fiber diameter
% composition of myelin = 70-80% lipid; 20-30% protein

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| Ion Concentration (mM) - SQUID NEURON | | |
|---|---|---|
| | Intracellular | Extracellular |
| Potassium | 400 | 20 |
| Sodium | 50 | 440 |
| Chloride | 40-150 | 560 |
| Calcium | 0.0001 | 10 |
| | | |
| Ion Concentration (mM) - MAMMALIAN NEURON | | |
| | Intracellular | Extracellular |
| Potassium | 140 | 5 |
| Sodium | 5-15 | 145 |
| Chloride | 4-30 | 110 |
| Calcium | 0.0001 | 1-2 |
| Data from Purves et al., Neuroscience, Sunderland: Sinauer Associates, 1997. | | |

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## Neurotoxins

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## Blood Supply

% brain utilization of total resting oxygen = 20%
% blood flow from heart to brain = 15-20% (Kandel et al., 2000)
Blood flow through whole brain (adult) = 750-1000 ml/min
Blood flow through whole brain (adult) = 54 ml/100 g/min
Blood flow through whole brain (child) = 105 ml/100 g/min
Cerebral blood flow = 55 to 60 ml/100 g brain tissue/min
Cerebral blood flow (gray matter) = 75 ml/100 g brain tissue/min
Cerebral blood flow (white matter) = 45 ml/100 g brain tissue/min (Rengachary, S.S. and Ellenbogen, R.G., editors, *Principles of Neurosurgery*, Edinburgh: Elsevier Mosby, 2005)

Oxygen consumption whole brain = 46 $cm^3$/min
Oxygen consumption whole brain = 3.3 ml/100 g/min
Blood flow rate through each carotid artery = 350 ml/min (Kandel et al., Principles of Neural Science, New York: McGraw Hill, 2000)
Blood flow rate through basilar artery = 100-200 ml/min (Kandel et al., 2000)
Diameter of vertebral artery = 2-3 mm
Diameter of common carotid artery (adult) = 6 mm
Diameter of common carotid artery (newborn) = 2.5 mm

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