PtN: External Media

Here is a list of movies and other media mentioned in the book *From Photon to Neuron* (Princeton University Press). Some of these are available directly via links below; in other cases, the link below takes you to the original journal article's media section (you may need an institutional subscription to view those ones). If your browser balks when you click a link, you may succeed by instead copying it, then pasting it into the browser's address space.

#1: Audio files shotNoise.aiff and shotNoise.mp3 contain clicks representing the arrival times of actual photon detection events. (Experimental data courtesy John F Beausang and Yale E Goldman.) Files 60Hz.aiff and 60Hz.mp3 contain uniformly spaced clicks with the same mean rate for comparison. File pprocess.aiff and pprocess.m4a contain simulated clicks drawn from a Poisson process with the same mean rate for comparison.

#2: Richard Feynman giving the lectures that became his book *QED:*
http://vega.org.uk/video/subseries/8 .

#3: The jellyfish *Aequorea victoria* viewed under normal illumination, and also as it appears in the dark when disturbed: http://biolum.eemb.ucsb.edu/organism/pictures/aequoreagfp.html = perma.cc/469L-GQ56 . More bioluminescent organisms: http://biolum.eemb.ucsb.edu/organism/photo.html = perma.cc/32YN-Q4C3 .

#4: Video images of endoscopic detection, and removal, of precancerous tissue.
http://lcom.epfl.ch/page-104022-en.html = perma.cc/8JT3-QDEF or
Bronchoscopy-DAFE-CIS.mp4 : In vivo detection of human bronchial carcinoma in situ (CIS) by autofluorescence bronchoscopy versus white light illumination.
HexvixHALdetection.mp4 : In vivo photodetection of flat lesions (CIS) in human bladder with ALA-Hexylester cystoscopy versus with white light.

#5: Animated model of voltage-gated sodium channel opening:
http://www.pnas.org/content/suppl/2011/12/08/1118434109.DCSupplemental = Catterall2014EPhMovieS1Side.mov
(Yarov-Yarovoy et al. Structural basis for gating charge movement in the voltage sensor of a sodium channel. Proc. Natl. Acad. Sci. USA (2012) vol. 109 (2) pp. E93–E102).

#6: Basic ideas of optogenetics: http://syntheticneurobiology.org/videos ; http://www.youtube.com/watch?v=QA67v4vSg00 .
Introduction to optogenetics, including control of turning in a mouse: http://www.youtube.com/watch?v=I64X7vHSHOE ;
http://www.youtube.com/watch?v=88TVQZUfYGw ;
https://www.youtube.com/watch?v=v7uRFVR9BPU , or Gradinaru-etal-ChR2Mouse-small.mp4 (originals: from the supplement to Gradinaru et al. Targeting and readout strategies for fast optical neural control in vitro and in vivo. Journal of Neuroscience (2007) vol. 27 (52) pp. 14231–14238) http://www.jneurosci.org/content/27/52/14231/suppl/DC1.
Optogenetic control of aggression in a mouse (from the supplement to Lin et al. Functional identification of an aggression locus in the mouse hypothalamus. Nature (2011) vol. 470 (7333) pp. 221–226):
https://static-content.springer.com/esm/art%3A10.1038%2Fnature09736/MediaObjects/41586_2011_BFnature09736_
and https://static-content.springer.com/esm/art%3A10.1038%2Fnature09736/MediaObjects/41586_2011_BFnature097
supplemental movies 3–4 at https://www.nature.com/articles/nature09736#Sec16 .
Optogenetic control of body motion and egg-laying in a nematode:
http://www.nature.com/nmeth/journal/v8/n2/full/nmeth.1554.html#supplementary-information (from the supplement to Leifer et al. Optogenetic manipulation of neural activity in freely moving *Caenorhabditis elegans*. Nat. Methods (2011) vol. 8 (2) pp. 147–152).
Introduction to optogenetics, including restoration of vision in a mouse: http://www.ted.com/talks/ed_boyden.html
Optogenetic restoration of vision in blind mouse (from Doroudchi et al. Virally delivered channelrhodopsin-2 safely and effectively restores visual function in multiple mouse models of blindness. Mol Ther (2011) vol. 19 (7) pp. 1220–1229): http://www.youtube.com/watch?v=jY5Aynh1-cU ;
Other therapeutic vistas: http://www.youtube.com/watch?v=NuF_D6N3kQs .
Detailed introduction to optogenetics: http://www.youtube.com/watch?v=PSbNCoImUTA .

#7: a: http://www.nature.com/nmeth/journal/v9/n1/extref/nmeth.1782-S2.avi : "Fluorescence from an HEK cell expressing Arch. The cell was subjected to steps in voltage from $-100\,\mathsf{mV}$ to $100\,\mathsf{mV}$ at 1 Hz. The apparent voltage-sensitive pixels inside the cell are due to out-of-focus fluorescence from the upper and lower surfaces of the plasma membrane. Images are unmodified raw data. Movie is shown in real time." (Kralj et al. Optical recording of action potentials in mammalian neurons using a microbial rhodopsin. Nat. Methods (2012) vol. 9 (1) pp. 90–95, Supplement.)
b: http://www.nature.com/nmeth/journal/v11/n8/fig_tab/nmeth.3000_SV4.html : See captions for each of the movies on this web page. [Hochbaum et al. All-optical electrophysiology in mammalian neurons using engineered microbial rhodopsins. Nat. Methods (2014) vol. 11(8) pp. 825–833.]

#8: Two-photon imaging videos showing activity of microglia in intact brain:
http://cshprotocols.cshlp.org/site/imaging_neuroscience/ , chapter 87. Video 87_1: Animation of side views from different virtual viewpoints (see Figure 2.17). Videos 87_2–3: Dynamic character of processes extending and retracting from microglia cell. Video 87_4: Phagocytosis (clearance) of damaged-cell debris by microglia. See full descriptions in Nimmerjahn et al. Resting microglial cells are highly dynamic surveillants of brain parenchyma in vivo. Science (2005) vol. 308 (5726) pp. 1314–1318.

#9: http://www.youtube.com/watch?v=1DJOTEDBA2c : A mouse (lower center) is run on a spherical treadmill. The mouse never actually moves, but the movements it imparts to the treadmill are used to "move" through a virual world that is projected on a wraparound screen. Two-photon imaging is used throughout the experiment to monitor activity in populations of neurons that would normally keep track of where the animal is in a real environment.
Dombeck et al. Imaging large-scale neural activity with cellular resolution in awake, mobile mice. Neuron (2007) vol. 56 (1) pp. 43–57;
Harvey et al. Intracellular dynamics of hippocampal place cells during virtual navigation. Nature (2009) vol. 461 (7266) pp. 941–946;
Dombeck et al. Functional imaging of hippocampal place cells at cellular resolution during virtual navigation. Nature Neurosci. (2010) vol. 13 (11) pp. 1433–1440.

#10: File RochDiffractPhoton.mov contains a movie of the buildup of a diffraction pattern, along with a growing histogram of the frequencies of various camera pixel x-coordinates. Every time a camera pixel recorded a blip, the corresponding pixel in the animation is turned on, and stays on. This way you can see the estimated probability density function build up gradually. The final image is what you might see if all of those photons arrived in a short burst, too fast for you eye to resolve. Similarly in the histogram, for each photon the bin corresponding to the photon's x value is incremented, eventually building up the estimated PDF as a graph. (Jean-François Roch, François Treussart, and Philippe Grangier). See also http://www.youtube.com/watch?v=bNGv86BKnvM and http://www.youtube.com/watch?v=MbLzh1Y9POQ .

#11: See http://www.vega.org.uk/video/programme/66. After the initial pomp and ceremony you can fast-forward to the key segment beginning around 22:00 minutes through 31:30. The diffraction pattern begins around 29:15 minutes. (Actually, the whole lecture is great.) Or see Tonomura et al. Demonstration of single-electron buildup of an interference pattern. Am. J. Phys. (1989) vol. 57 pp. 117–120.

#12: See http://www.youtube.com/watch?v=f8oV4RBYR9U for the amazing archerfish.

#13: Files myoV.mov and myoV.avi show motion of the molecular motor myosin-V. Myosin-V was labeled by the fluorescent dye rhodamine (green) and is seen walking along actin filaments labeled with Alexa 647 (blue). The actin filaments in turn are attached to a quartz microscope slide, in the presence of $5\,\mu\mathsf{M}$ ATP. The motion consists of about four steps per second, giving an overall speed of about $140\,\mathsf{nm/s}$. (Courtesy John F Beausang and Yale E Goldman.)

#14:
GelfandAggregation.mov: Aggregation of melanosomes in zebrafish.
GelfandDispersion.mov: Dispersion of melanosomes in zebrafish.
GelfandMelanosomeMT.avi: Traffic of melanosomes along microtubules during dispersion of pigment in *Xenopus*

melanophores.
(Courtesy Vladimir I. Gelfand, Northwestern University Feinberg School of Medicine. See also: Park M, Serpinskaya AS, Papalopulu N, Gelfand VI. Rab32 regulates melanosome transport in *Xenopus* melanophores by protein kinase a recruitment. Curr Biol. 2007 Dec 4;17(23):2030–4.)

#15: See Supplementary Movie S1 at
http://www.sciencemag.org/content/suppl/2003/06/25/1084398.DC1/1084398S1.mov: "Movement of a single fluorescent dye attached to myosin V for the lower right trace shown in Fig. 3. Each pixel is 86 nm. Discrete 74-nm steps are clearly visible." (Supplement to A Yildiz et al. Myosin V walks hand-over-hand: Single fluorophore imaging with 1.5-nm localization. Science (2003) vol. 300 (5628) pp. 2061–2065.)
Alternative: FIONA-Yildiz.mp4.

#16: Betzig1127344s1.mp4, Betzig1127344s1.mov: "Partial summed molecule TIRF image (center) and PALM image (right) constructed during the acquisition of 300 single molecule frames (left) out of the 20 000 frames used to construct the images in Fig. 2. Scale bar is 0.5 μm." [Supplement to E Betzig et al. Imaging intracellular fluorescent proteins at nanometer resolution. Science (2006) vol. 313 (5793) pp. 1642–1645.]
Similar processing applied to lights on the Eiffel Tower: Eiffel.mov= https://www.youtube.com/watch?v=RE70GuMCzww (realization by Ricardo Henriques).

#17: Animation depicting the principle of interferometric PALM imaging:
http://www.pnas.org/content/suppl/2009/02/06/0813131106.DCSupplemental/SM1.mov and
http://www.pnas.org/content/suppl/2009/02/06/0813131106.DCSupplemental/SM2.mov (captions are in
http://www.pnas.org/content/suppl/2009/02/06/0813131106.DCSupplemental/0813131106SI.pdf).

#18: DNAanimation.mov: Rotating image of DNA structure. (Animation courtesy Kevin Towles.)

#19: See http://ocean.si.edu/giant-squid = perma.cc/CC5L-KSND, especially the video.

#20: Howard Berg's *E. coli* movies show several aspects of flagellar propulsion:
http://www.rowland.harvard.edu/labs/bacteria/index_movies.html .
For example, when a flagellum is anchored to a surface, its motor spins the entire bacterium, making it easy to see switching between clockwise and counterclockwise rotation:
http://www.rowland.harvard.edu/labs/bacteria/movies/tethered.php = ChemotaxisBergTethered-ecoli-2.mov.mov .
Other short videos show the resulting bundling and unbundling of flagella:
http://www.rowland.harvard.edu/labs/bacteria/movies/ecoli.php = berg-fluo-fil-leave.mov .
Also, show the class G. I. Taylor's classic video, "Low Reynolds Hydrodynamics," available at http://web.mit.edu/hml/ncfmf.html
It is also available at: http://www.youtube.com/watch?v=51-6QCJTAjU .

#21: See RodSynapseKey.pdf = perma.cc/2X2Y-JJYD for a key to the structures shown in Figure 10.13.

#22: It is possible to experience colors not normally found in our color space. After prolonged exposure to a static field of red light, say, the red receptors adapt (temporarily lose sensitivity). Suddenly switching to a green field can then give a ratio of L to M photoreceptor activity lower than what is ordinarily possible, resulting in a startling effect. See http://www.skytopia.com/project/illusion/ipage-et.html = perma.cc/XZ3S-89NN.
Here, too is the shocking "castle illusion": johnsadowski_castle_anim.gif; castleIllusionMcColloughEffect.gif.

#23: File photoreceptorSim.mov contains a simulation of pigment molecules (dots) absorbing photons in a photoreceptor.

#24: The infrared activity of carbon dioxide gas: https://www.youtube.com/watch?v=0eI9zxZoipA .