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Emerging Trends in Visual Science Communication: How to create informative and inspiring graphics for journals and presentations

Shizuka Aoki

University of Massachusetts Medical School

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National Library of Medicine - Webinar Series

May 4th, 2017

Shizuka Aoki

Founder & Creative Lead, **Anatomize Studios Inc.**

Co-Founder, **BioRender.io**

Science illustrator, **National Geographic Magazine**

www.anatomize.com

aoki@anatomize.com

TODAY'S TALK (60 min):

Brief background

What is science/medical illustration?

Tools & techniques (and common mistakes!)

Q&A

Giveaway

(1 free customized science graphic, at end of talk, valued at \$500)

WHY SCIENCE VISUALIZATION?

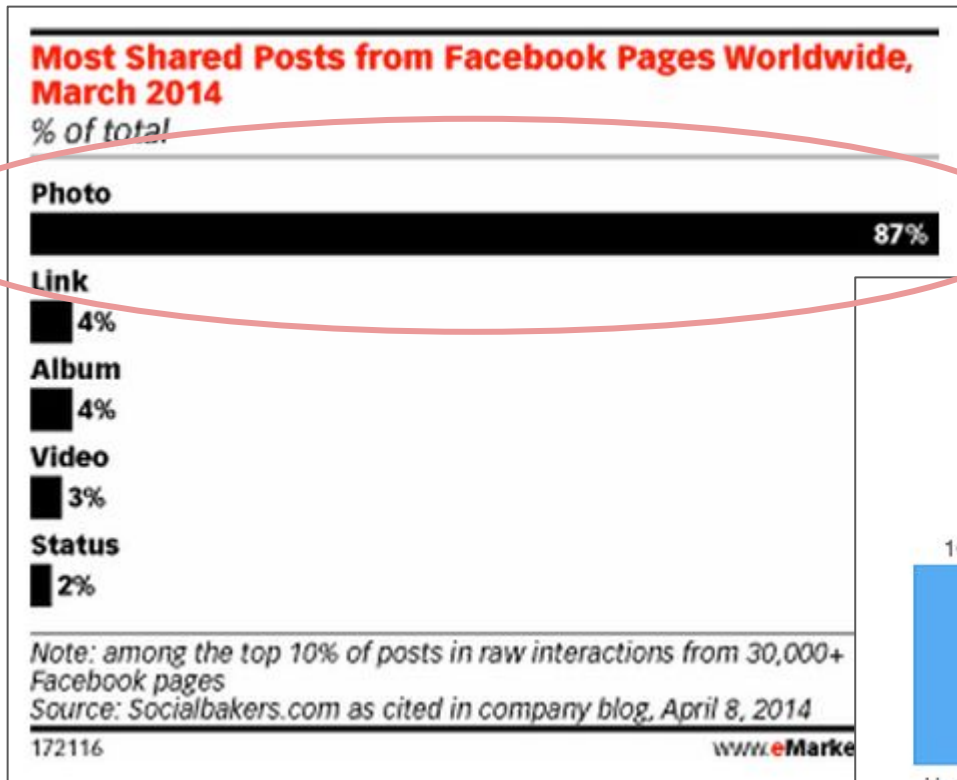
SCIENCE VISUALIZATION

VALUE OF A GOOD SCIENTIFIC GRAPHIC:

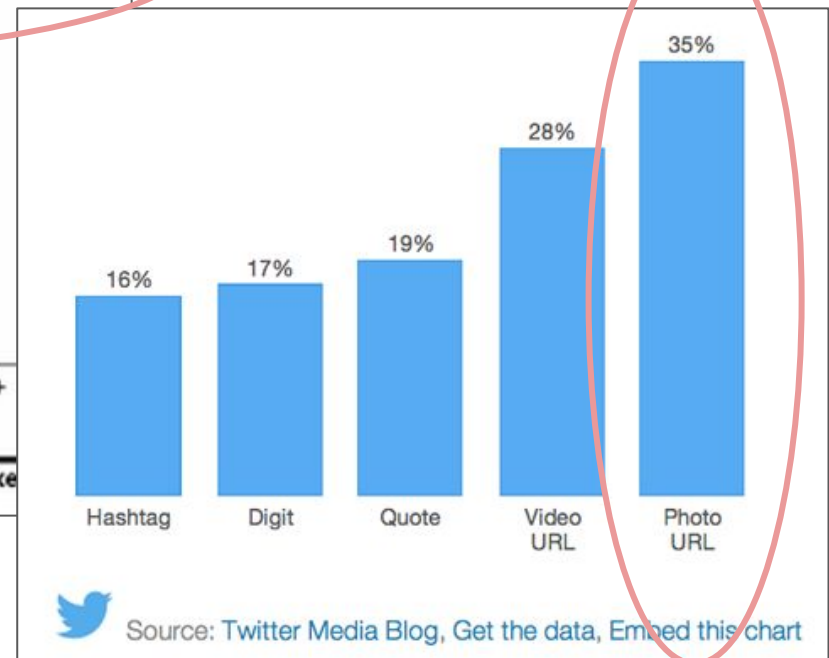
- Communication - peer to peer, or to the public
- Publication
- Presentation slides
- Investors (VC pitch decks)
- Self-evaluation
- Promotional / Social media

SCIENCE VISUALIZATION

Facebook



Twitter



SCIENCE VISUALIZATION

'Eight reasons I rejected your article'

ELSEVIER

SEARCH CART

1. It fails the technical screening.

Before they even go to the editor-in-chief, articles are checked for technical elements. The main reasons they are rejected are:

Peter Thrower, PhD, is Editor-in-Chief of Carbon, the international journal of the American Carbon Society, and Professor Emeritus of Material Sciences and Engineering at Penn State University.

- The article contains elements that are suspected to be plagiarized, or it is currently under review at another journal. (Republishing articles or parts of articles, submitting to one or more journals at the same time or using text or images without permission is not allowed. See our ethical guidelines.)
- The manuscript is not complete; it may be lacking key elements such as the title, authors, affiliations, keywords, main text, references and all tables and figures).
- The English is not sufficient for the peer review process,
- The figures are not complete or are not clear enough to read.
- The article does not conform to the Guide for Authors for the journal it is submitted to.

<https://www.elsevier.com/connect/8-reasons-i-rejected-your-article>

BACKGROUND

BACKGROUND

BSc. Life Science

Queen's University, Kingston ON

BFA, Fine Art

Queen's University, Kingston ON

MA, Medical Illustration

Johns Hopkins University School of Medicine, Baltimore, MD

BACKGROUND

National Geographic Magazine HQ, Washington, DC



BACKGROUND

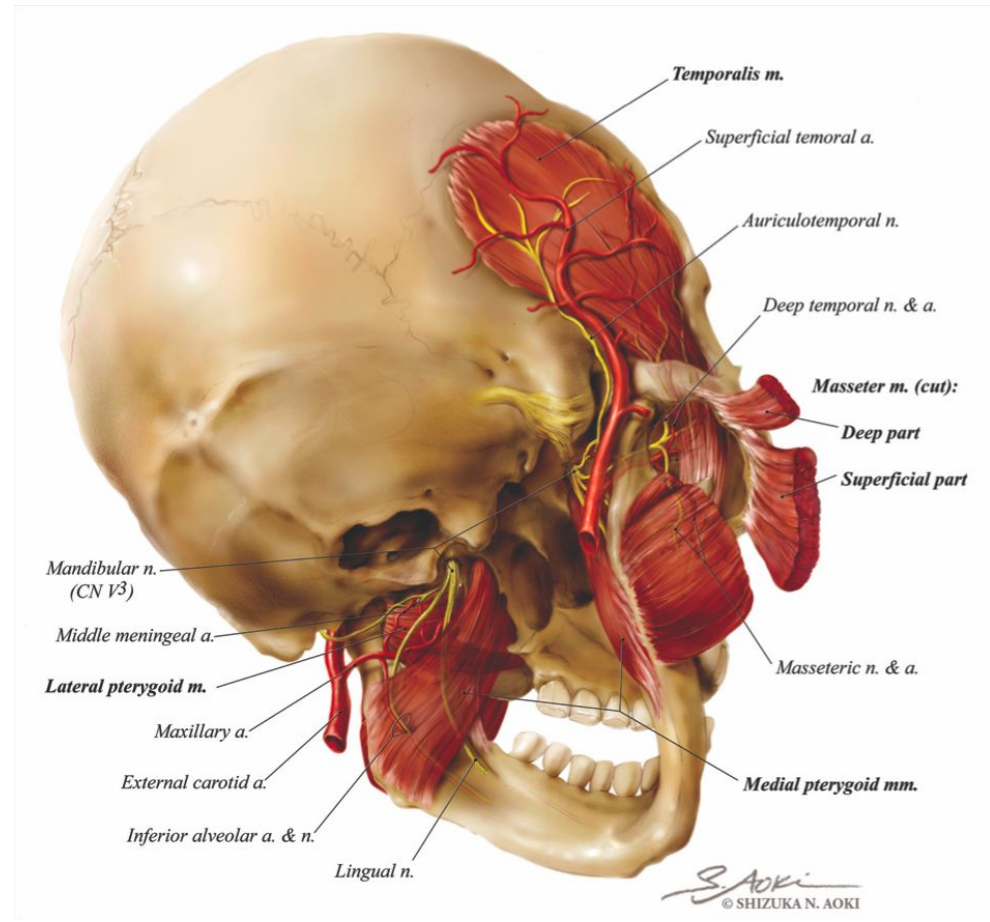
National Geographic Magazine HQ, Washington, DC







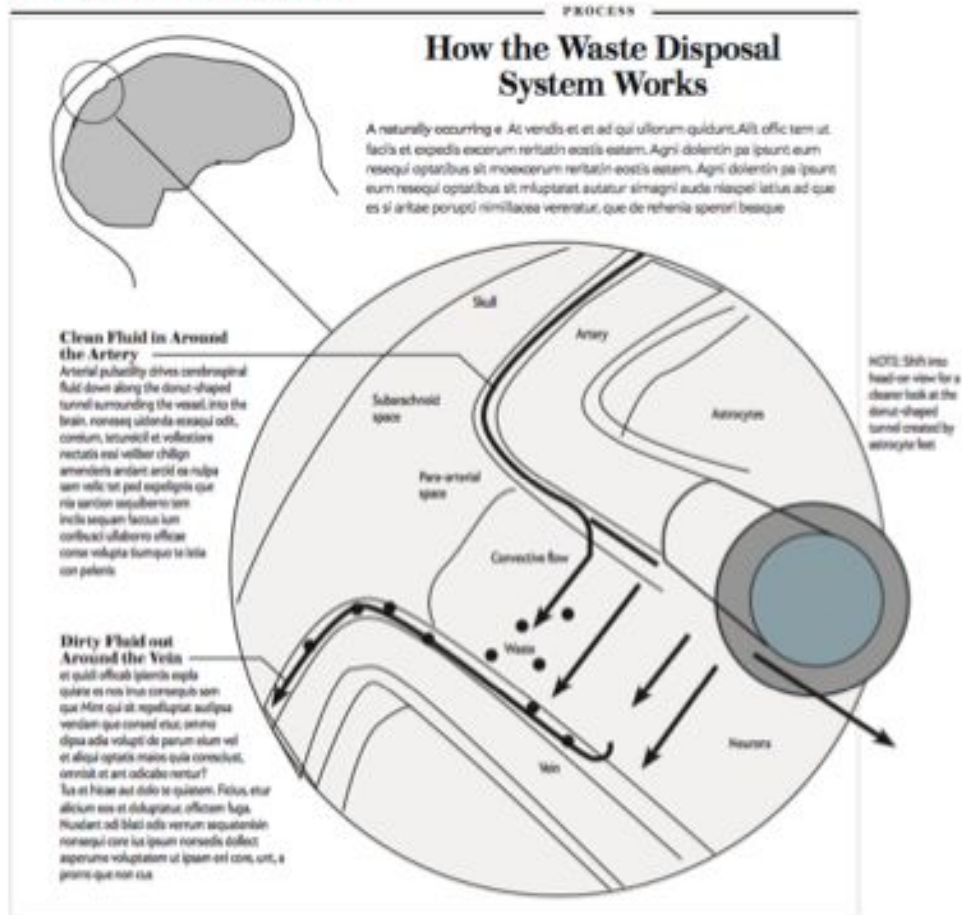






PEAK INTO THE PROCESS

ROUGH CONCEPT SKETCH



mostly of endothelial cells and smooth muscle cells that line the vasculature throughout the body. But the outer wall is unique to the brain and spinal cord.

It is made up of a projecting extension from a type of brain cell called an astrocyte, which performs a multitude of support functions for the interconnected network of neurons that relay signals throughout the organ by the trillions. The extensions called astrocytic endfeet completely surround the arteries, capillaries, and veins in the brain and spinal cord, forming the outer enclosure for the perivascular space. The hollow tube-like

cavity remains largely free of obstructions, creating a spillway that provides scant resistance for the rapid transport of fluid through the brain.

Scientists knew about the existence of the perivascular space, but had not identified any specific function for it. Twenty years ago, Patricia Grady at the University of Maryland reported - in a set of studies that proved seminal only in retrospect - that large proteins injected into the cerebrospinal fluid could later be found in the perivascular spaces, of both dog and cats. At the time, other groups could not replicate her findings

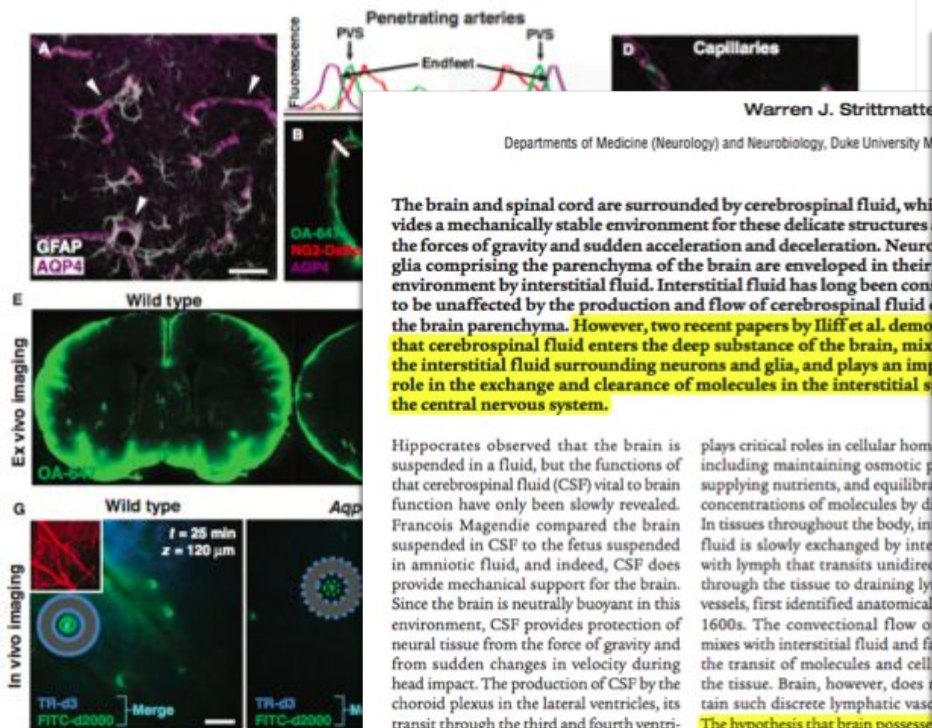


Fig. 4. Paravascular AQP4 facilitates CSF flux through the brain. (A) AQP4 (purple) is specifically expressed in brain astrocytes where localization is highly polarized to perivascular endfeet (arrows) and (B and C) AQP4-positive perivascular astrocytic endfeet immersed around the para-arterial CSF influx pathway. Plots depict fluorescence intensity projections from (B) and (C), indicated by white rectangles (green) is localized within the paravascular space (PVS), between capillary smooth muscle (red) and the astrocytic endfeet (purple), movement along the capillary basal lamina (green) is bounded by vascular AQP4-positive endfeet (purple). (E and F) The core AQP4-mediated fluid flux to the movement of subarachnoid and through the brain parenchyma was evaluated *ex vivo*. Water labeling was quantified, the movement of intracranially injected into the brain was significantly reduced in Aqp4-null mice compared to wild-type (WT) controls 30 min after injection ($p = 4$ to 5 per cent).

Warren J. Strittmatter
Departments of Medicine (Neurology) and Neurobiology, Duke University Medical Center, Durham, NC, USA

The brain and spinal cord are surrounded by cerebrospinal fluid, which provides a mechanically stable environment for these delicate structures. The forces of gravity and sudden acceleration and deceleration. Neuroglia comprising the parenchyma of the brain are enveloped in their environment by interstitial fluid. Interstitial fluid has long been considered to be unaffected by the production and flow of cerebrospinal fluid (CSF) in the brain parenchyma. However, two recent papers by Iliff et al. demonstrate that cerebrospinal fluid enters the deep substance of the brain, mixes with the interstitial fluid surrounding neurons and glia, and plays an important role in the exchange and clearance of molecules in the interstitial space of the central nervous system.

Hippocrates observed that the brain is suspended in a fluid, but the functions of that cerebrospinal fluid (CSF) vital to brain function have only been slowly revealed. Francois Magendie compared the brain suspended in CSF to the fetus suspended in amniotic fluid, and indeed, CSF does provide mechanical support for the brain. Since the brain is neutrally buoyant in this environment, CSF provides protection of neural tissue from the force of gravity and from sudden changes in velocity during head impact. The production of CSF by the choroid plexus in the lateral ventricles, its transit through the third and fourth ventricles, its coursing over the exterior surface of the brain and spinal cord, and its ultimate uptake at the arachnoid granulations in the large draining veins was not fully described until the early 1900s (Figure 1A and ref. 1).

Into the soup

Virtually every cell throughout the body is surrounded by interstitial fluid, which

Conflict of interest: The author has declared that no conflict of interest exists.

Citation for this article: *Clin Invest*. doi:10.1177/15382241

plays critical roles in cellular homeostasis, including maintaining osmotic pressure, supplying nutrients, and equilibrating concentrations of molecules by diffusion. In tissues throughout the body, interstitial fluid is slowly exchanged by interstitial lymph that transits unidirectionally through the tissue to draining lymphatic vessels, first identified anatomically by Virchow in 1800s. The convective flow of lymph mixes with interstitial fluid and facilitates the transit of molecules and cells throughout the tissue. Brain, however, does not contain such discrete lymphatic vessels. The hypothesis that brain possesses a 'phatic' system with the same phylogenetic functions, but with different anatomy, that found throughout the rest of the body, was initially proposed based on the observations that CSF is removed from the neonatal brain through the venous system in the choroid plexus, and additionally, that CSF flows unidirectionally along the ependymal lining in the ventricles, which is the only arachnoid granulation in the brain. Injections of radiolabeled albumin into the CSF showed that half of the albumin tracer

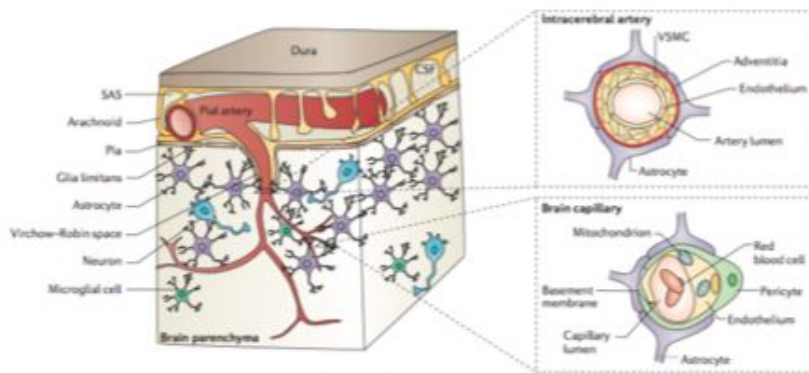


Figure 1 | Cerebral microcirculation and the neurovascular unit. In the brain, glial arteries run through the subarachnoid space (SAS), which contains the cerebrospinal fluid (CSF). These vessels give rise to intracerebral arteries, which penetrate into brain parenchyma. Intracerebral arteries are separated from brain parenchyma by a single, interrupted layer of elongated fibroblast-like cells of the pia and the astrocyte-derived glia limitans membrane that forms the outer wall of the perivascular Virchow-Robin space. These arteries branch into smaller arteries and subsequently arterioles, which lose support from the glia limitans and give rise to pre-capillary arterioles and brain capillaries. In an intracerebral artery, the vascular smooth muscle cell (VSMC) layer occupies most of the vessel wall. At the brain capillary level, vascular endothelial cells and pericytes are attached to the basement membrane. Pericyte processes encase most of the capillary wall, and they communicate with endothelial cells directly through gap-junctional contacts containing connexins and N-cadherin. Astrocyte endfeet processes encase the capillary wall, which is composed of endothelium and pericytes. Resting microglia have a 'ramified' shape and can sense neuronal injury.

Cerebral amyloid angiopathy

A vessel disease that is caused by the deposition of amyloid in the vessel wall of small cerebral arteries and capillaries, and that results in cerebral blood flow dysregulation, blood-brain barrier disruption and microhaemorrhages.

Amyloid-β

A small, 4-kDa peptide that accumulates in the brains of individuals with Alzheimer's disease. It forms neurotoxic oligomers and amyloid aggregates that are deposited in the brain parenchyma and around small cerebral blood vessels.

Neurovascular unit

A complex multicellular functional unit of the CNS comprising vascular cells, glial cells and neurons that, together, ultimately determine CNS activities and responses in health and disease.

Pericytes

Mural vascular cells that share a common basement membrane with brain capillary endothelial cells at one end, and that are in direct contact with astrocytes at the other.

This membrane underlies the BBB and limits the entry of plasma components, red blood cells (RBCs) and leukocytes into the brain. The BBB also regulates the delivery into the CNS of circulating energy metabolites and essential nutrients that are required for proper neuronal and synaptic function. Non-neuronal cells and neurons act in concert to control BBB permeability and CBB. Vascular cells and glia are primarily responsible for maintenance of the constant 'chemical' composition of the ISF, and the BBB and the blood-spinal cord barrier (BSCB) work together with pericytes to prevent various potentially neurotoxic and vasculotoxic macromolecules in the blood from entering the CNS, and to promote clearance of these substances from the CNS.

Transport across the blood-brain barrier. The endothelial cells that form the BBB are connected by tight and adherens junctions, and it is the tight junctions that confer the low paracellular permeability of the BBB¹¹. Small lipophilic molecules, oxygen and carbon dioxide diffuse freely across the endothelial cells, and hence the BBB, but normal brain endothelium lacks fenestrations and has limited vesicular transport.

The high number of mitochondria in endothelial cells reflects a high energy demand for active ATP-dependent transport, conferred by transporters such as the sodium pump (Na^+/K^+ ATPase) and the ATP-binding cassette (ABC) efflux transporters. Sodium influx and potassium

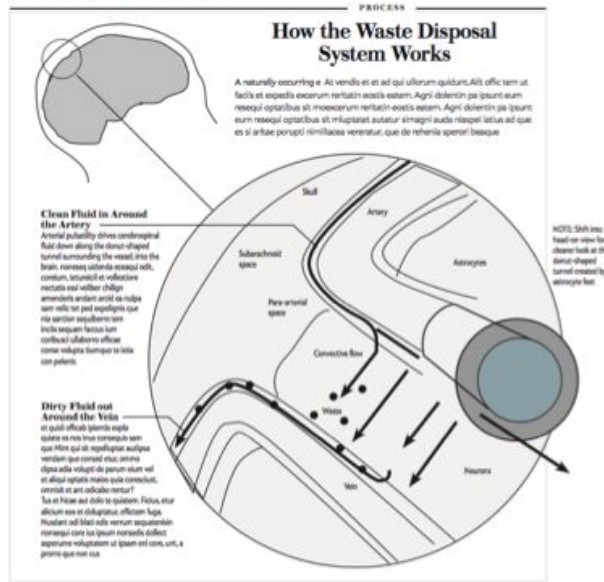
efflux across the abluminal side of the BBB is controlled by (Na^+/K^+ ATPase) (Fig. 2). Changes in sodium and potassium levels in the ISF influence the generation of action potentials in neurons and thus directly affect neuronal and synaptic functions¹².

Brain endothelial cells express transporters that facilitate the transport of nutrients down their concentration gradients, as described in detail elsewhere^{13,14} (Fig. 2). Glucose transporter 1 (GLUT1; also known as solute carrier family 2, facilitated glucose transporter member 1 (SLC2A1)) — the BBB-specific glucose transporter — is of special importance because glucose is a key energy source for the brain.

Monocarboxylate transporter 1 (MCT1), which transports lactate, and the L1 and y-amino acid transporters are expressed at the luminal and abluminal membranes^{15,16}. Sodium-dependent excitatory amino acid transporter 1 (EAAT1), EAAT2 and EAAT3 are expressed at the abluminal side of the BBB¹⁷ and enable removal of glutamate, an excitatory neurotransmitter, from the brain (Fig. 2). Glutamate clearance at the BBB is essential for protecting neurons from overstimulation of glutamatergic receptors, which is neurotoxic¹⁸.

ABC transporters limit the penetration of many drugs into the brain¹⁹. For example, multidrug resistance protein 1 (ABCB1; also known as ATP-binding cassette subfamily B member 1) controls the rapid removal of ingested toxic lipophilic metabolites²⁰ (Fig. 2). Some

ROUGH CONCEPT SKETCH



mostly of endothelial cells and smooth muscle cells that line the vasculature throughout the body. But the outer wall is unique to the brain and spinal cord.

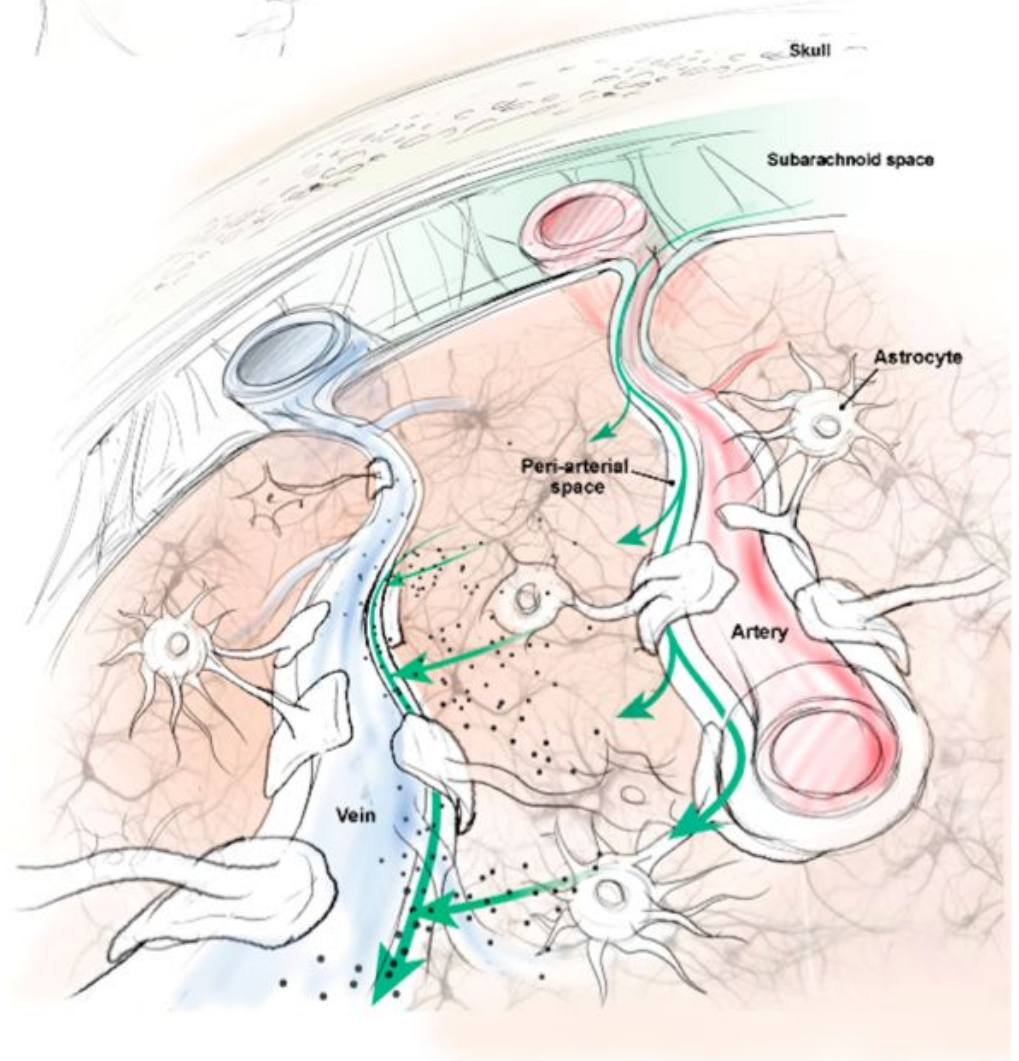
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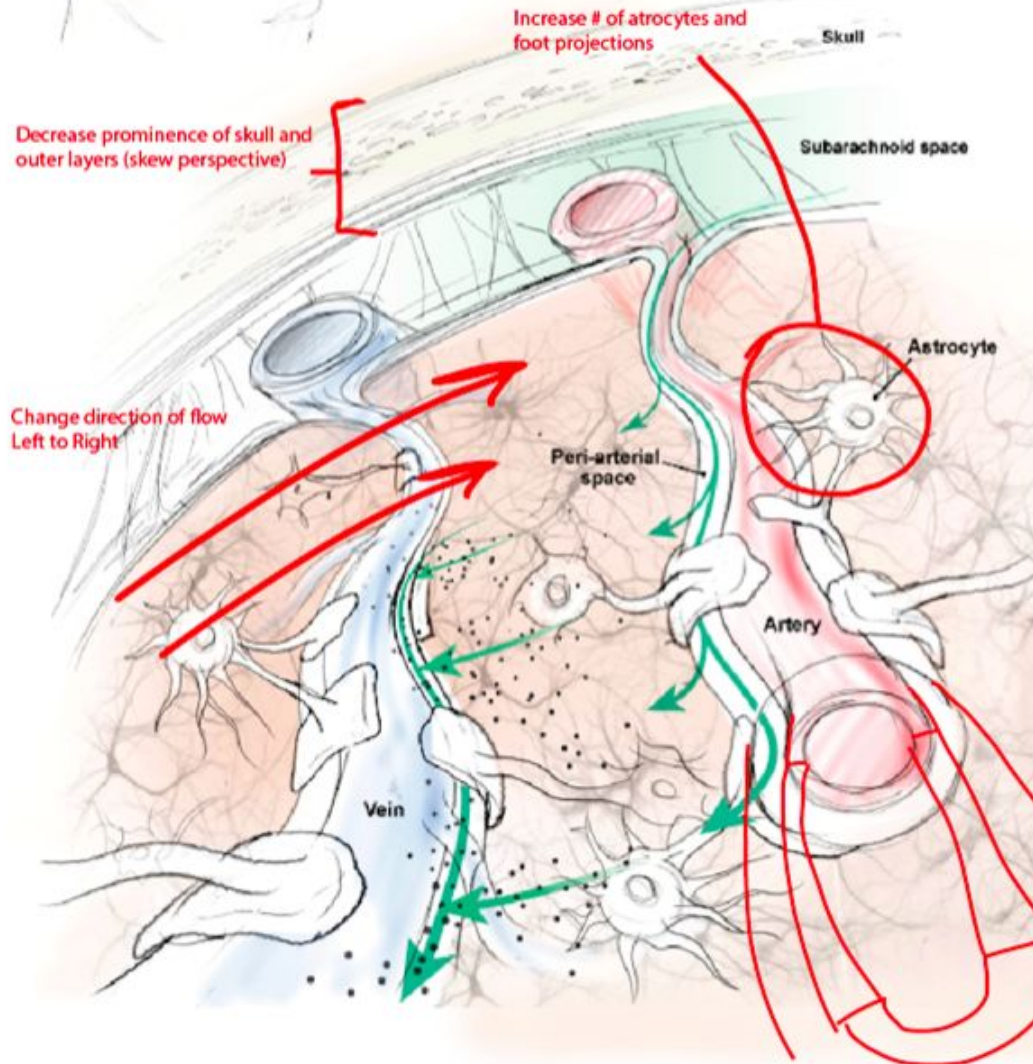
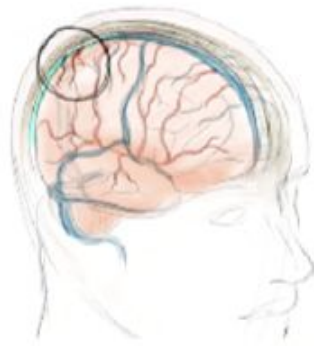
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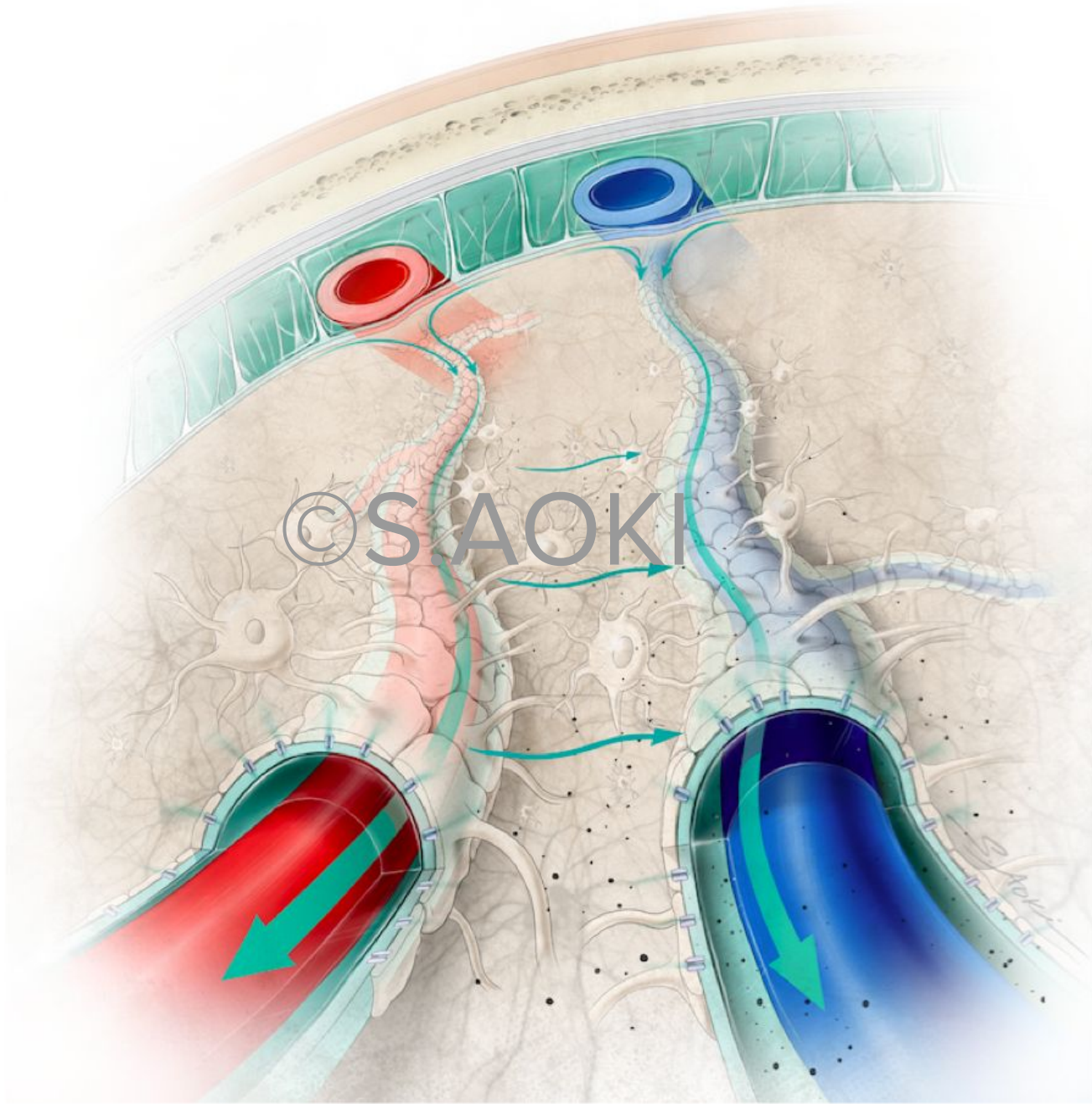
March 2015, ScientificAmerican.com 38

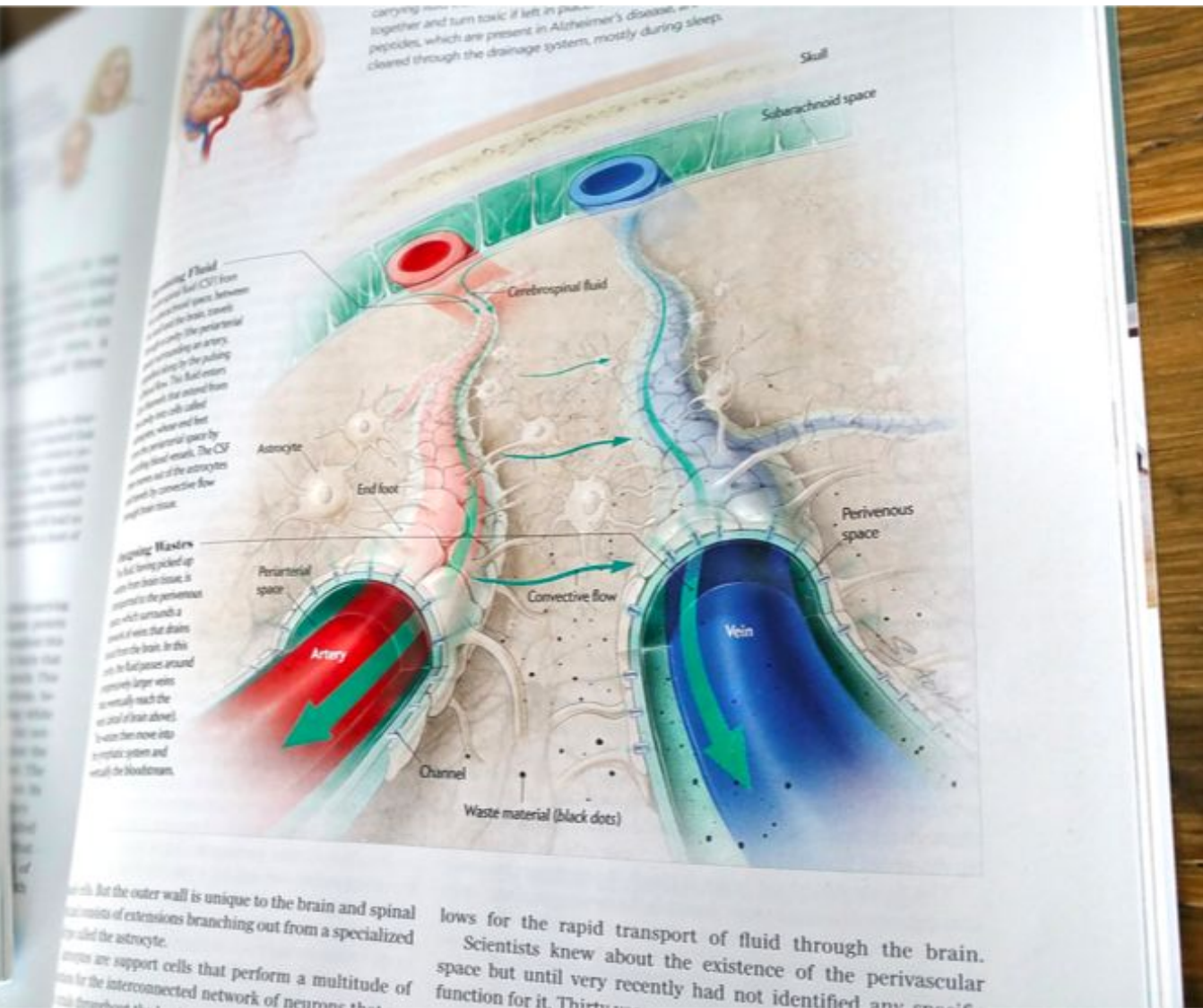
DRAFT for Scientific American - 'Glymphatics'
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Quest for the Enormous Theorem

Life at Hell's Gate

The Path from Wolf to Dog

SCIENTIFIC AMERICAN

Mystery of the Hidden Cosmos
Dark matter may be much weirder than physicists thought

ADVANCES

DEVELOPMENTAL BIOLOGY

First Impressions

We start to pick up words, food preferences and hand-eye coordination long before being born

Newborns are hardly blank slates devoid of knowledge and experience, contrary to historical notions about the infant mind. Sensory awareness and learning start in the womb, as the recently reinvigorated study of fetal per-

ception has made clearer than ever. In the past few years lifelike images and videos created by 3-D and 4-D ultrasounds have divulged much more about physiology and behavior than the blurry 2-D silhouettes of typical ultrasound.

And noninvasive activity in the developing new electrical activity in the developing brain of a fetus or newborn. Recent insights gleaned from such tools provide a rich portrait of how a fetus goes about budding brain and senses to learn about itself and the outside world well before birth. Such research has improved care for preterm babies, familiar and quiet voices of dim lights, familiar and quiet voices, and lots of comforting skin contact between mother and child. —*Ferris Jabr*

TOUCH

As early as seven weeks after fertilization, fetuses start to move. As they grow, they swing their umbilical cords, climb the walls of the amniotic sac and stick their limbs in their mouths. Much of this activity could be random fumbling, but recent 4-D-scanning studies suggest that by 24 weeks fetuses anticipate these motions, opening their mouth before bringing their hands toward it, for example. And their coordination improves as they grow.

HEARING AND LANGUAGE

A fetus begins to hear between 24 and 27 weeks. It has been known for a decade that fetuses learn general features of their native language, such as rhythm and intonation, but two studies in 2013 confirmed that they also pick up distinct words and syllables. Brain activity of newborns in one of those studies revealed that they recognized three-syllable nonsense words that had been repeatedly played in their environment prior to birth, whereas newborns never exposed to the words were indifferent.

SMELL AND TASTE

By the 15th week of pregnancy, a fetus's taste buds have formed. The olfactory cells in its nose are working around the 24th week. Studies in the past decade had shown that newborns prefer flavors and odors, such as garlic, anise and carrot, that they grew accustomed to in the womb. Other work with rats in the past couple of years suggest that the foods a mother eats can mold a fetus's brain in unhealthy ways, too. Baby rats whose mothers ate a diet of junk food were born with brains primed to crave such foods.

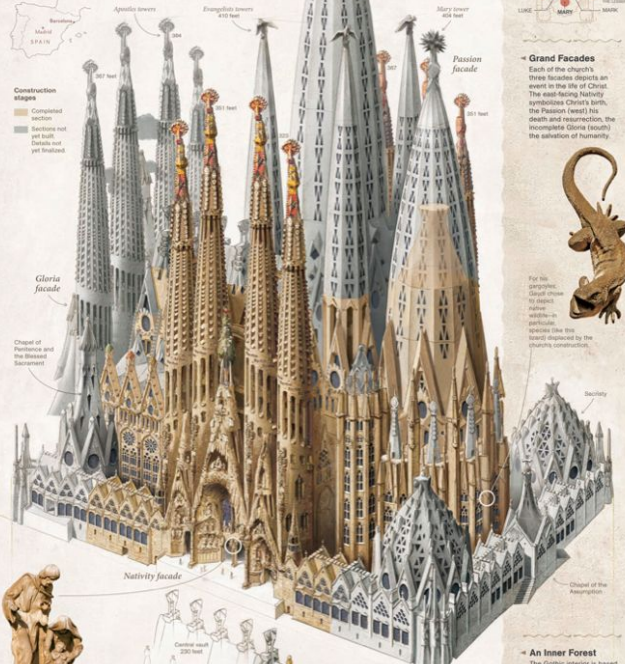
VISION

Of all the senses, vision takes longest to mature. A fetus does not open its eyes until its 28th week, and researchers debate what it can see, if anything. New evidence from animal studies indicates, however, that light filtering through the womb is crucial for eye development: when deprived of light, a mouse fetus will grow too many neurons and blood vessels in its eyes, causing damaging pressure to build up.

Fetus shown at 27 weeks

Barcelona's Natural Wonder

Financed entirely through private donations and tourist revenue, the Sagrada Família is inching closer to completion. A look at the church's layout and design reveals a marvel of imaginative—and unprecedented—engineering.



Construction stages
 Completed section
 Sections not yet built
 Details not yet finished

Gloria facade

Chapel of Penitence and the Blessed Sacrament



The only facade with sculptures designed by Gaudí himself. The Nativity focuses on the church's namesake: the Holy Family.

The total interior surface area of the church is 84,438 square feet and has room for over 8,000 people.

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A Work in Progress
 Here are some key steps in the church's slow march to completion.

Symbolic Towers
 Still unconstructed, the church's primary pillars will represent some of Christianity's most important figures: Jesus, Mary, the Gospel writers.



Grand Facades
 Each of the church's three facades depicts an event in the life of Christ. The east-facing Nativity symbolizes Christ's birth, the Passion (west) his death and resurrection, the incomplete Gloria (south) the salvation of humanity.



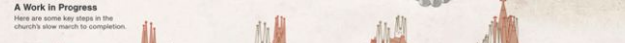
For his gargantuan lizard (now by design) and his sculptures, Gaudí was inspired by the church's construction.

An Inner Forest
 The Gothic interior is based on the Latin cross and set by initial architect Francisco del Villar. But Gaudí wanted the space to feel like a vibrant canopy. Columns rise like tree trunks before branching. Light is captured and reflected through a double roof.

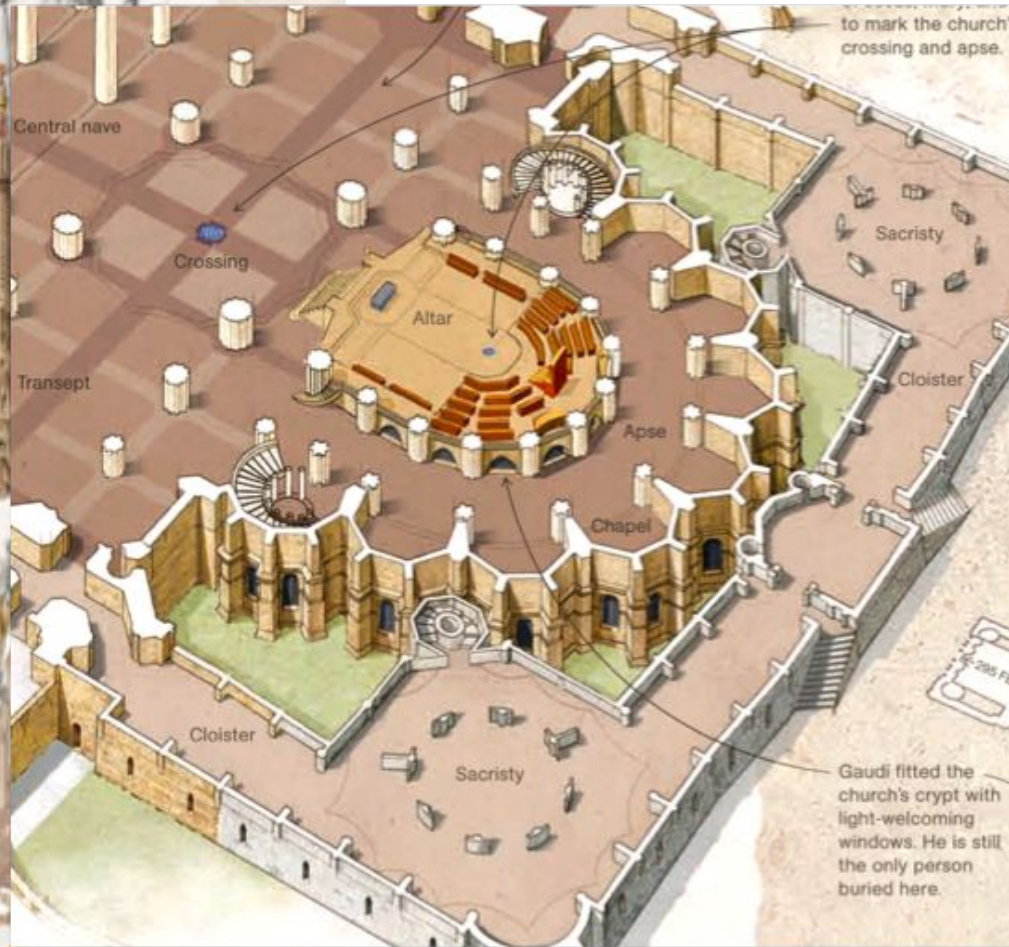


Gaudí designed choirs to house the joyful voices of Jesus, Mary, and Joseph to mark the church's infancy and apex.

Gaudí tried the church's design with light scattering windows, but he got the only pattern found here.



Barcelona's Natural Wonder



to mark the church's crossing and apse

Gaudi fitted the church's crypt with light-welcoming windows. He is still the only person buried here.



ALL ABOUT THE BENJAMINS

ORGANIC GROWTH

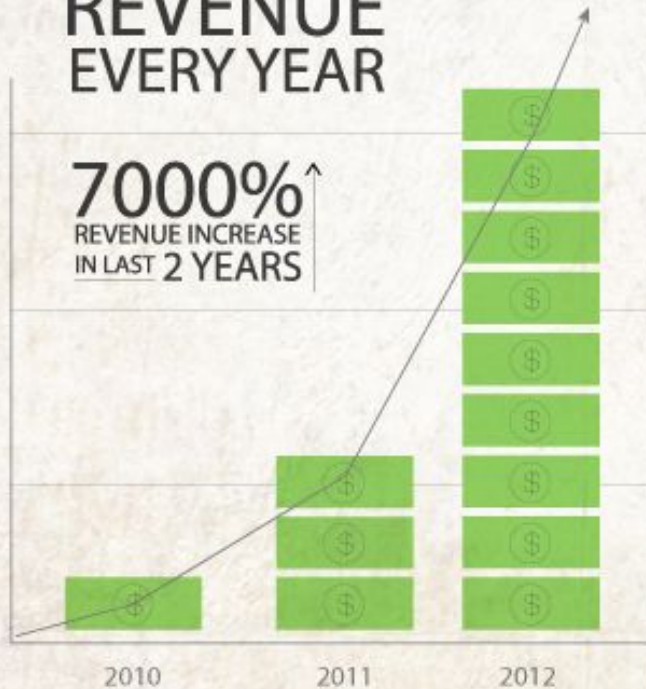


INITIAL self-funded
INVESTMENT:
\$45,000



TRIPLED REVENUE EVERY YEAR

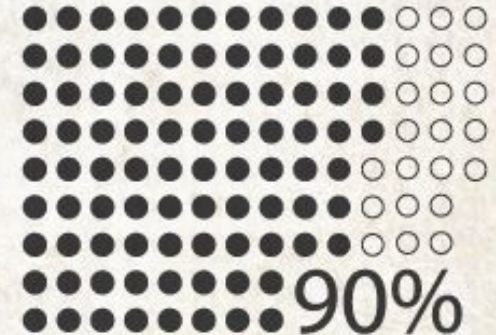
7000%
REVENUE INCREASE
IN LAST 2 YEARS



3

NUMBER OF
INVESTORS
TURNED DOWN

WEEKENDS WORKED



COMPANIES
LAUNCHED

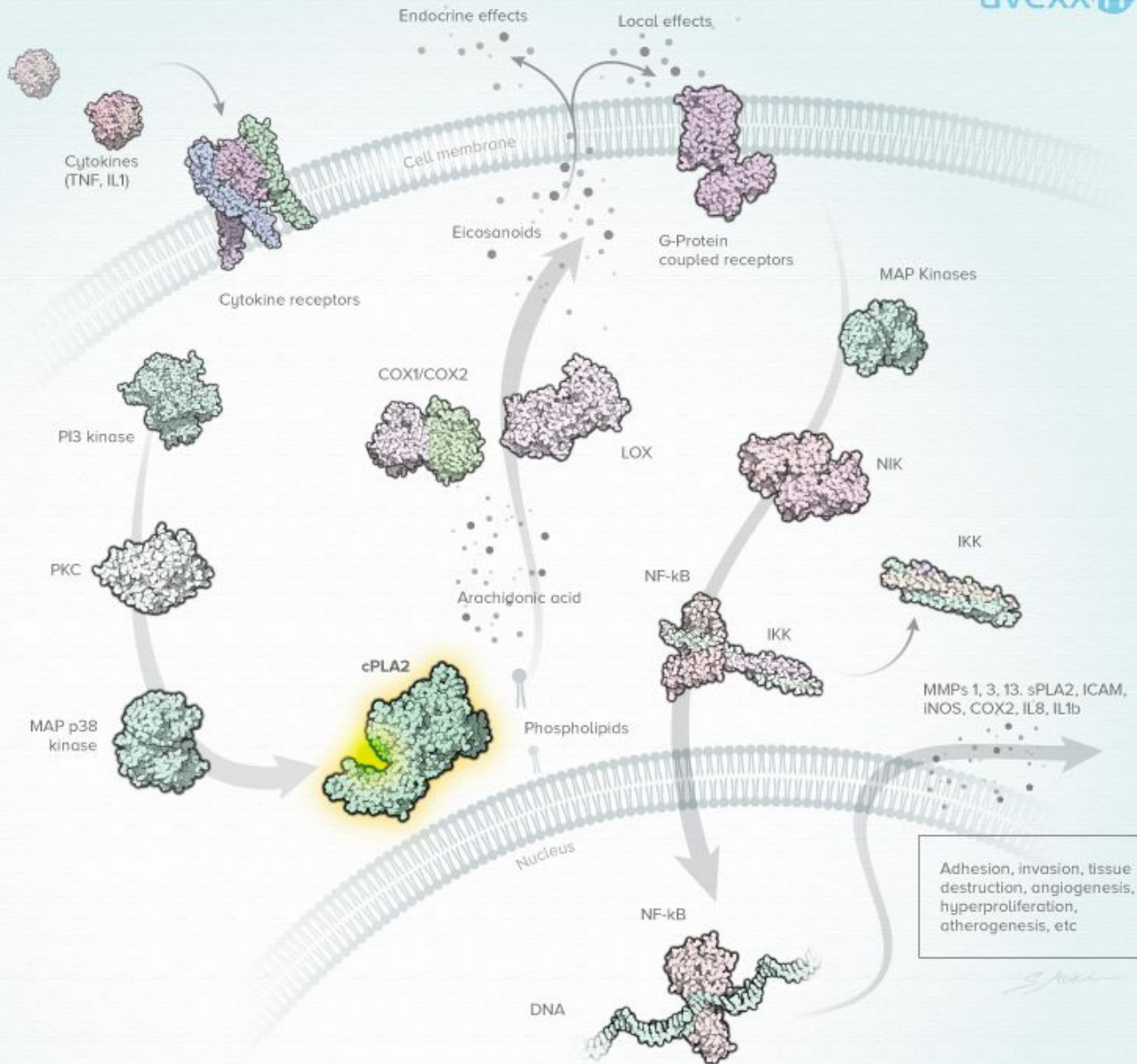
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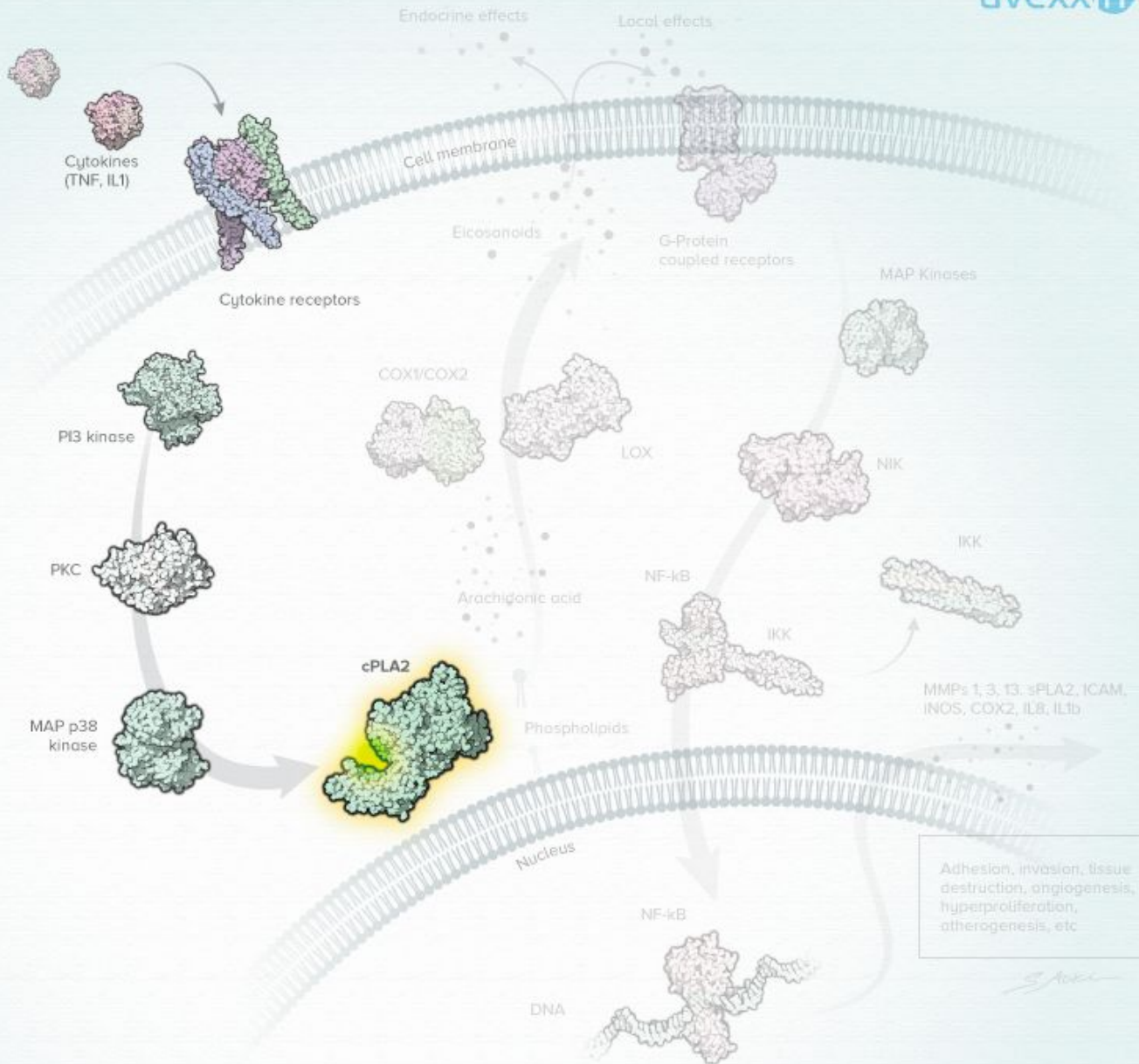
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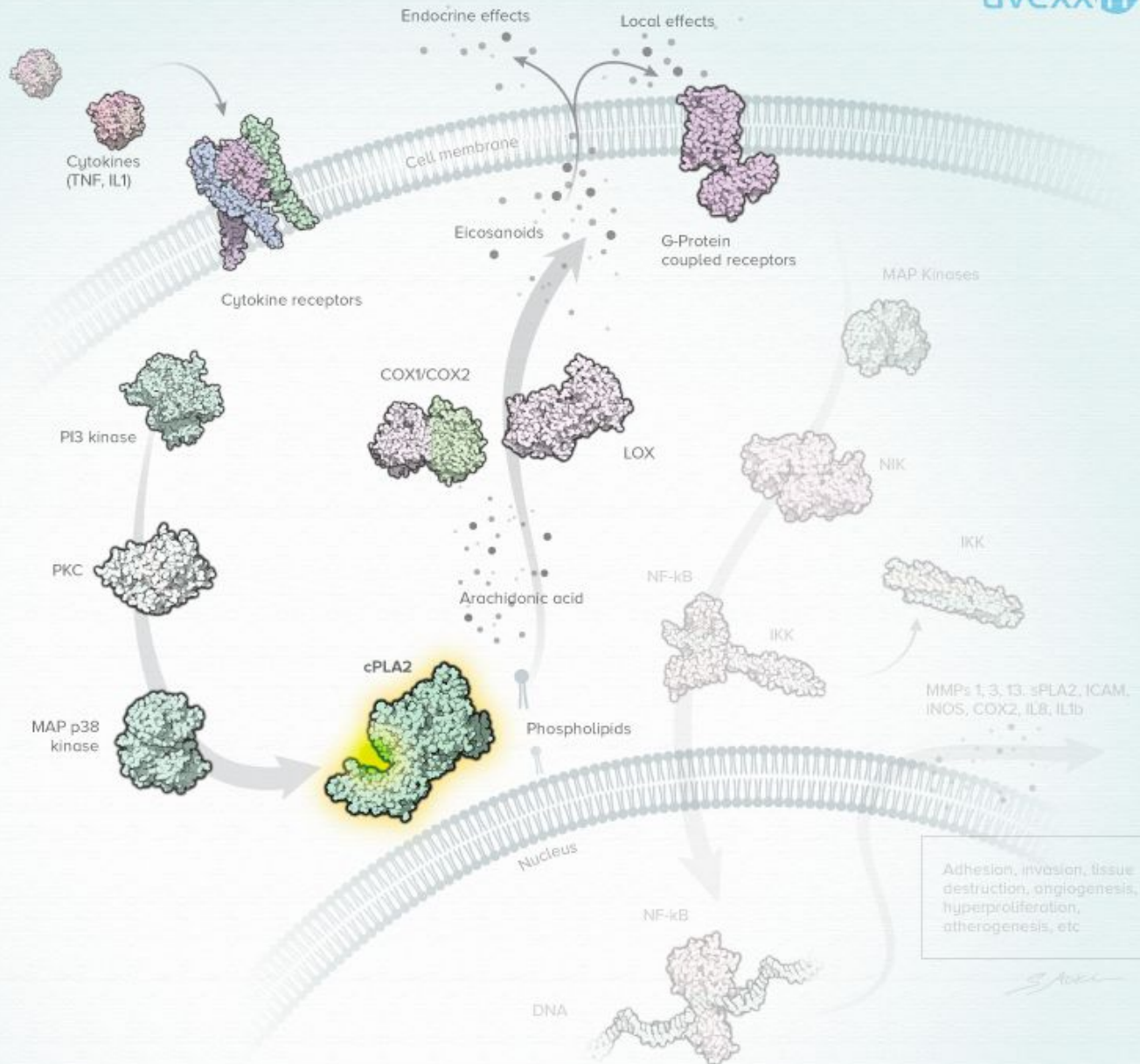
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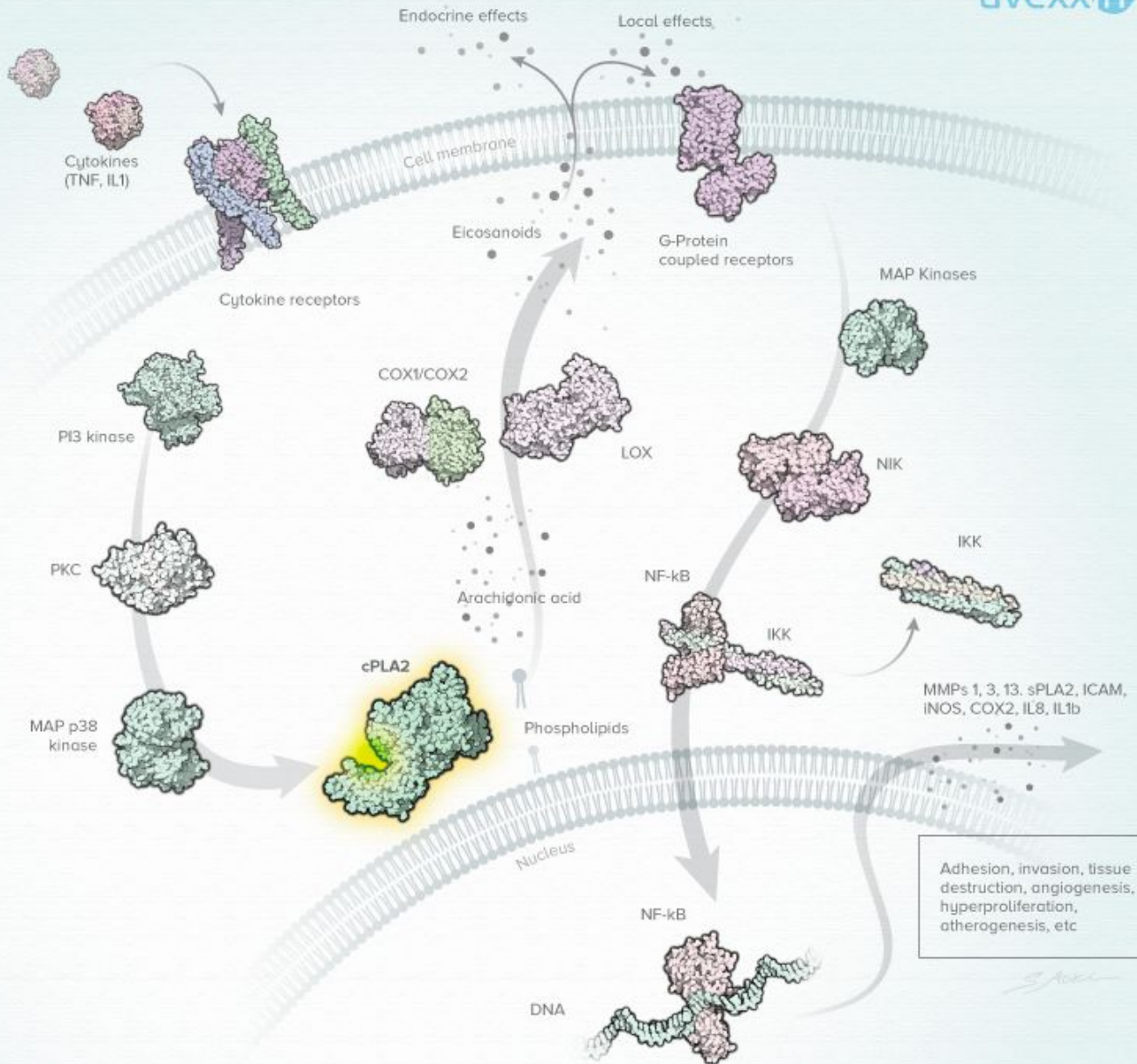
TBA











TOOLS & TECHNIQUES

HARDWARE

Wacom tablet

- Wacom Intuos series (tablet)
- Cintiq series (screen/tablet)

Macbook and iMac - iOS (all wacom products and most software compatible on both PC and Mac)



SOFTWARE

- Adobe Photoshop & Illustrator (80%)
- Adobe After Effects
- Screenflow ('whiteboard' type animations)
- ToonBoom (storyboarding)
- Google Drive (Google Drawing)
- Dropbox Paper (share ideas)
- Powerpoint (with a grain of salt...)
- QuteMol (free, beautiful 3D renders of Pymol or pdb files)

- Others (I have not tried but have been recommended)
 - Graph Pad
 - Mind the Graph (infographics online)

- Tutorials: Lynda.com, YouTube
- Squarespace.com (Easy website for startups, labs, products)

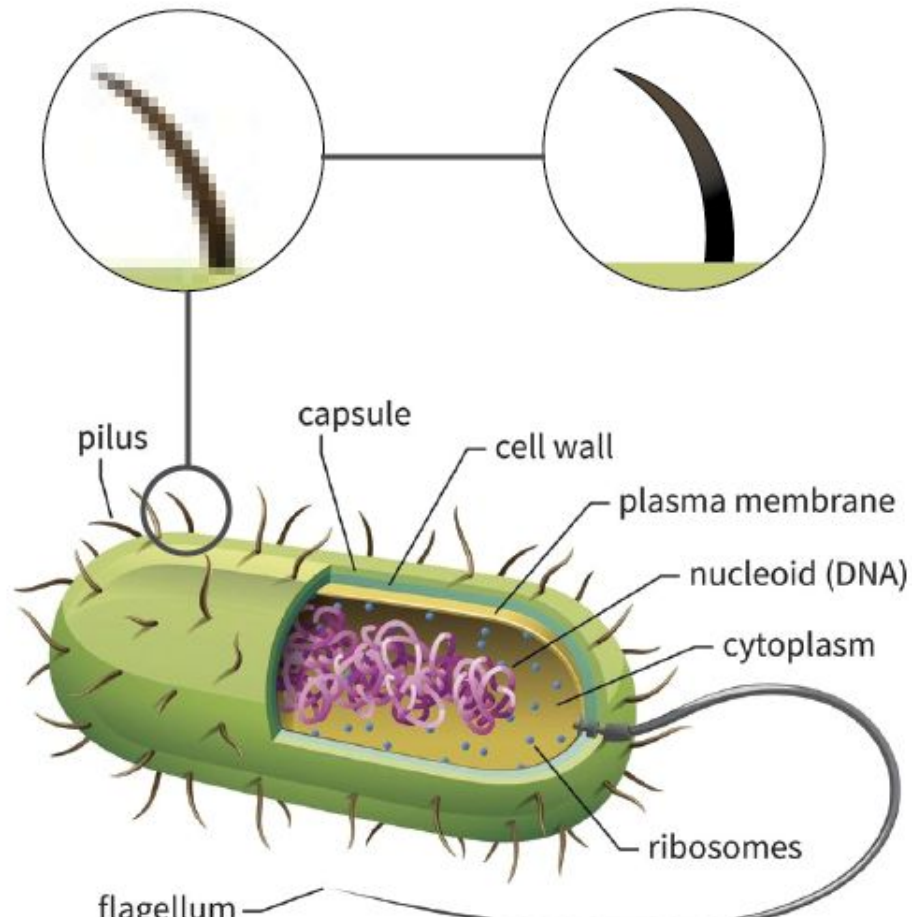
TECHNICAL BASICS

Raster (pixels)

jpgs, png, gif, pdf

Vector (paths)

ai, svg, pdf, eps



TECHNICAL BASICS

Lines, arrows, fonts, margins

- Watch your margins! Equal on all sides
- Pick 1 or 2 fonts!
- Fonts - kerning (in Photoshop/Illustrator, select “Optical”)
- Keep arrow strokes thinner than the text thickness
- Don't use dropshadows or rounded edges! (dated)

VISUAL DESIGN CHOICES - 'Kerning'



AV wa

The image shows the text 'AV wa' in a black serif font. The letters 'A' and 'V' are separated by a wide gap, and 'w' and 'a' are also separated by a wide gap. Vertical blue lines are drawn at the right edge of 'A' and the left edge of 'V', and at the right edge of 'w' and the left edge of 'a', highlighting the lack of adjustment between the letters.

No kerning



AV wa

The image shows the text 'AV wa' in a black serif font. The letters 'A' and 'V' are now closer together, and 'w' and 'a' are also closer together. Vertical blue lines are drawn at the right edge of 'A' and the left edge of 'V', and at the right edge of 'w' and the left edge of 'a', showing that the gaps have been reduced.

Kerning applied

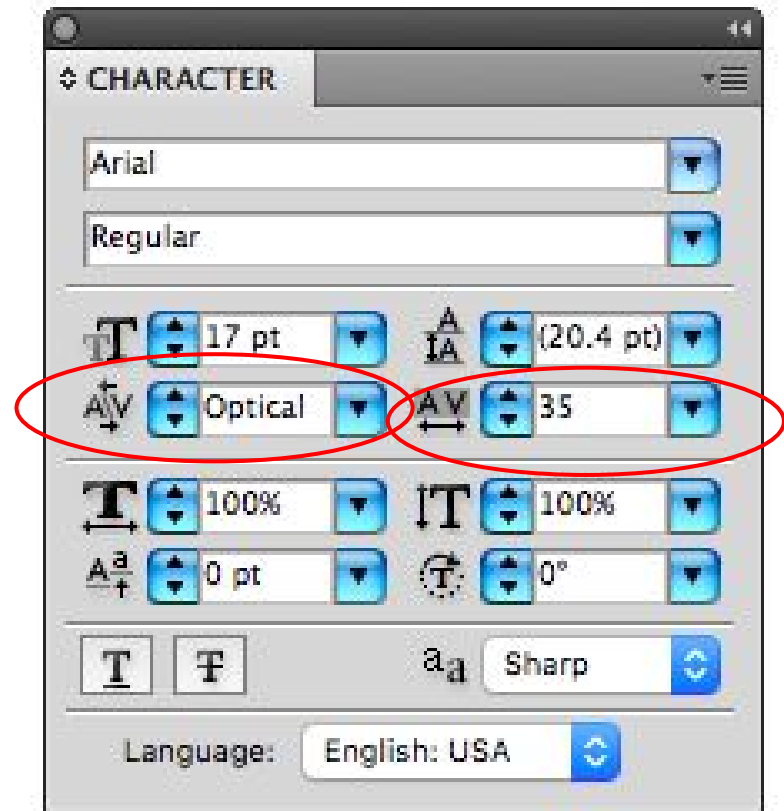
VISUAL DESIGN CHOICES - 'Kerning'

The cat in the hat

The cat in the hat

The cat in the hat

The cat in the hat



0g
Trans
Fat

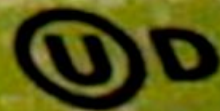


key lime

farts

THE
10g = 2oz \$2.99
BAKERY

8.6 oz. (245 g)



TECHNICAL BASICS

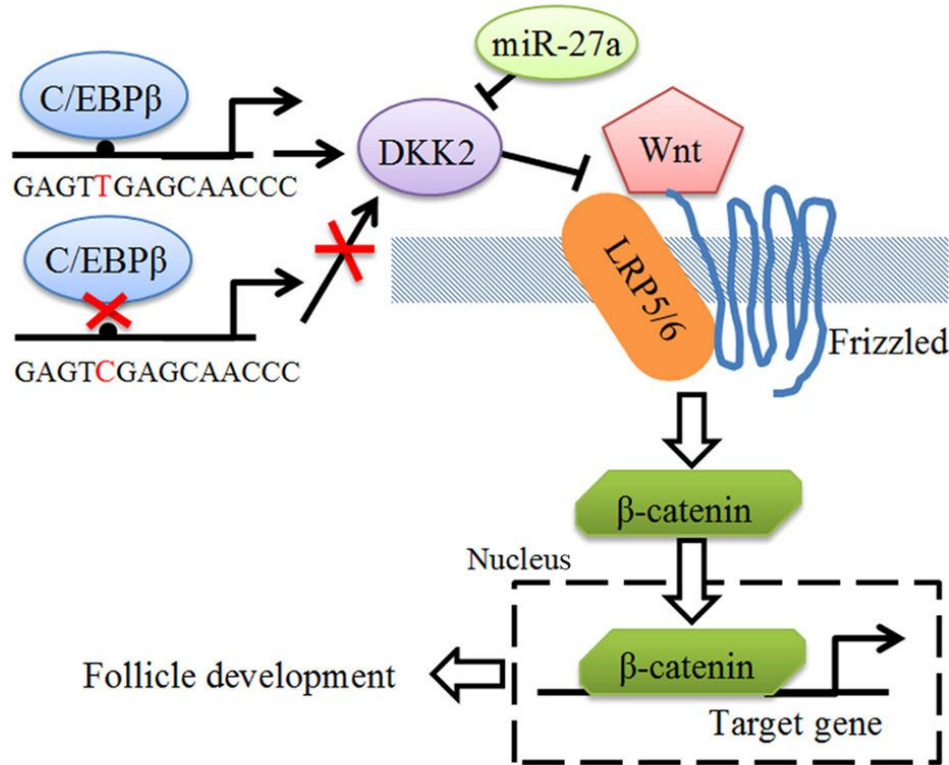
Color and Grayscale

- Don't use black, use dark grey
- Pick ONE accent color for slides and design
- Be careful of color “values”

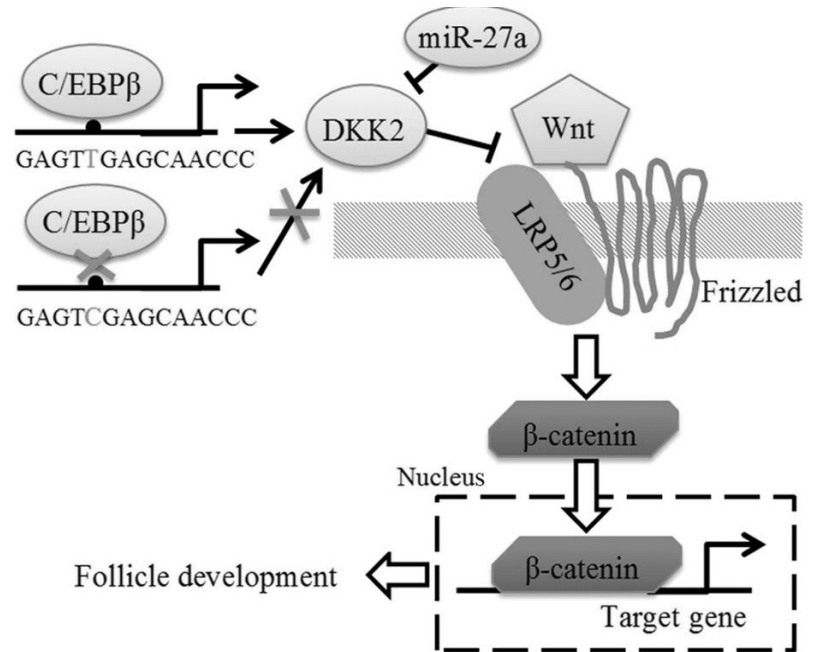
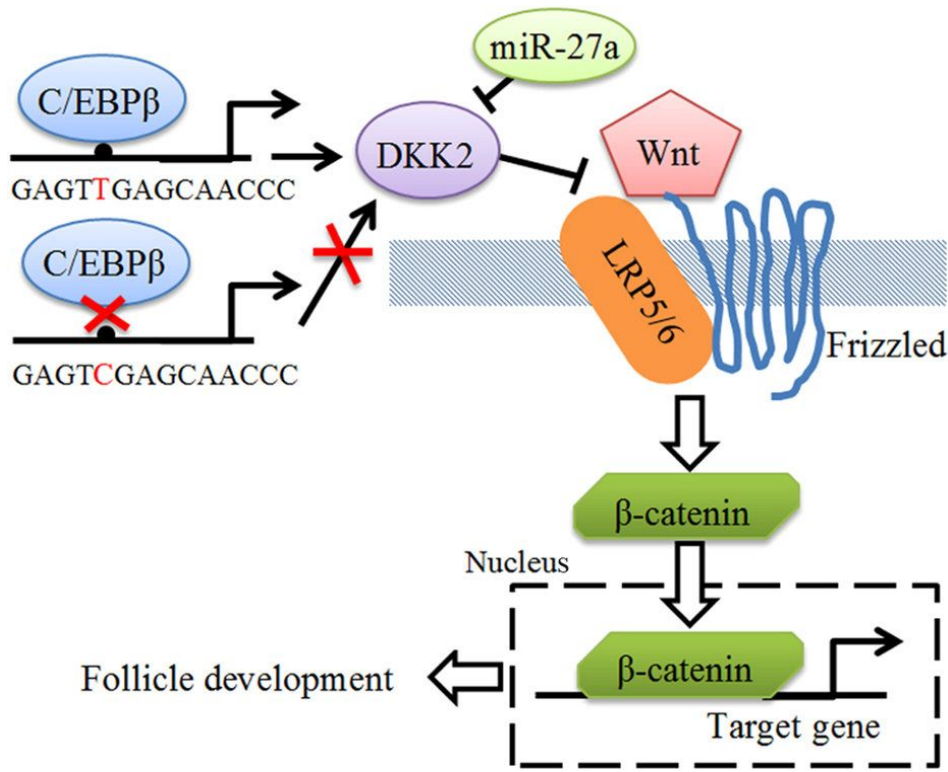
VISUAL DESIGN CHOICES - Color and “Value”



VISUAL DESIGN CHOICES - Color and “Value”



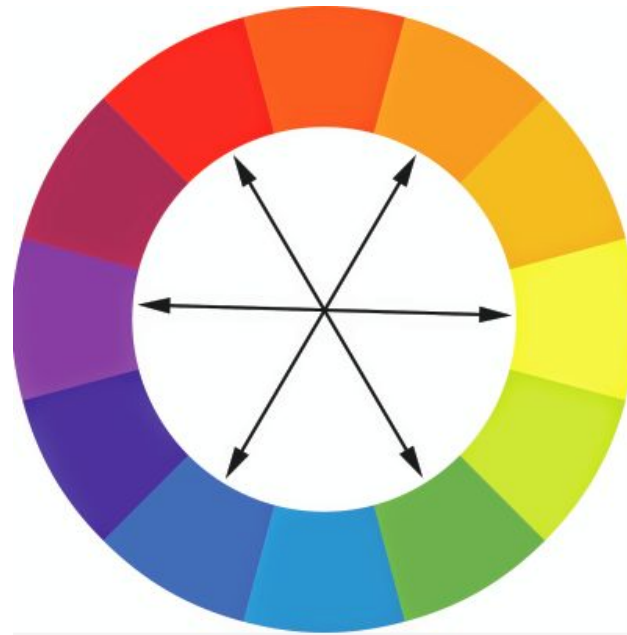
VISUAL DESIGN CHOICES - Color and "Value"



TECHNICAL BASICS

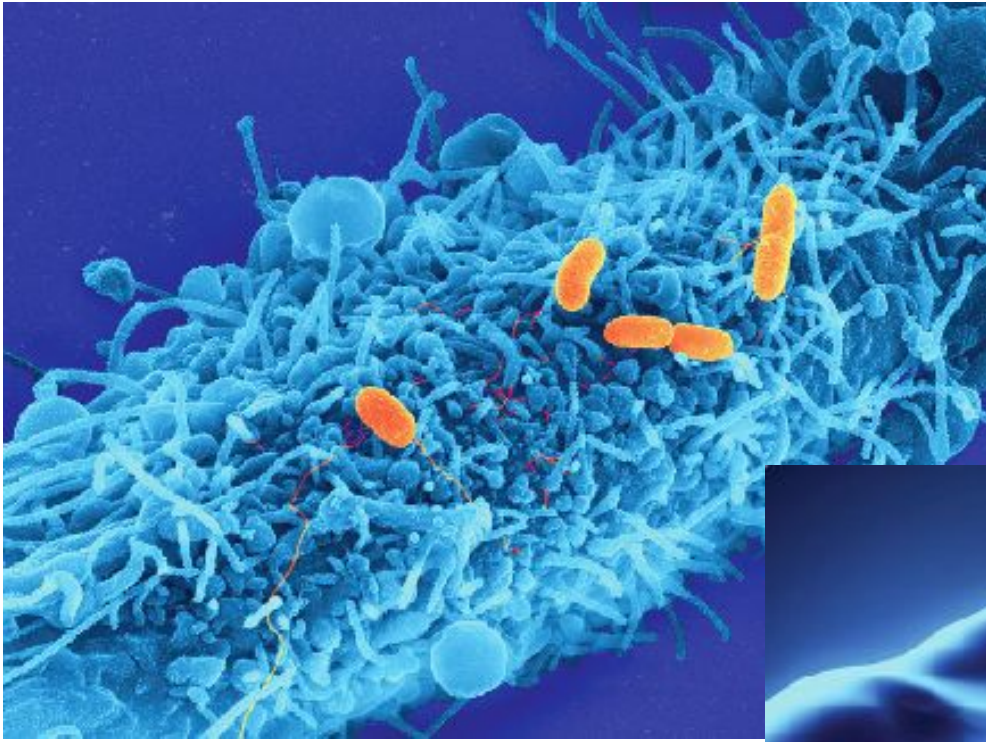
Science behind colors (use complementary hues)

Red + green
Orange + blue
Purple + yellow



VISUAL DESIGN CHOICES - Color and “Value”





TECHNICAL BASICS

THINGS TO AVOID:

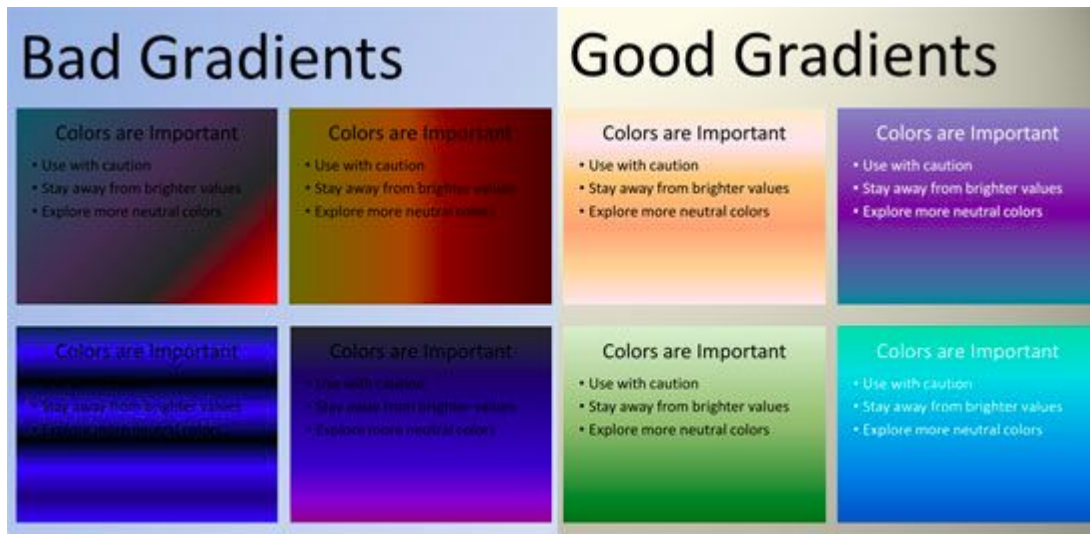
- Word Art



TECHNICAL BASICS

THINGS TO AVOID:

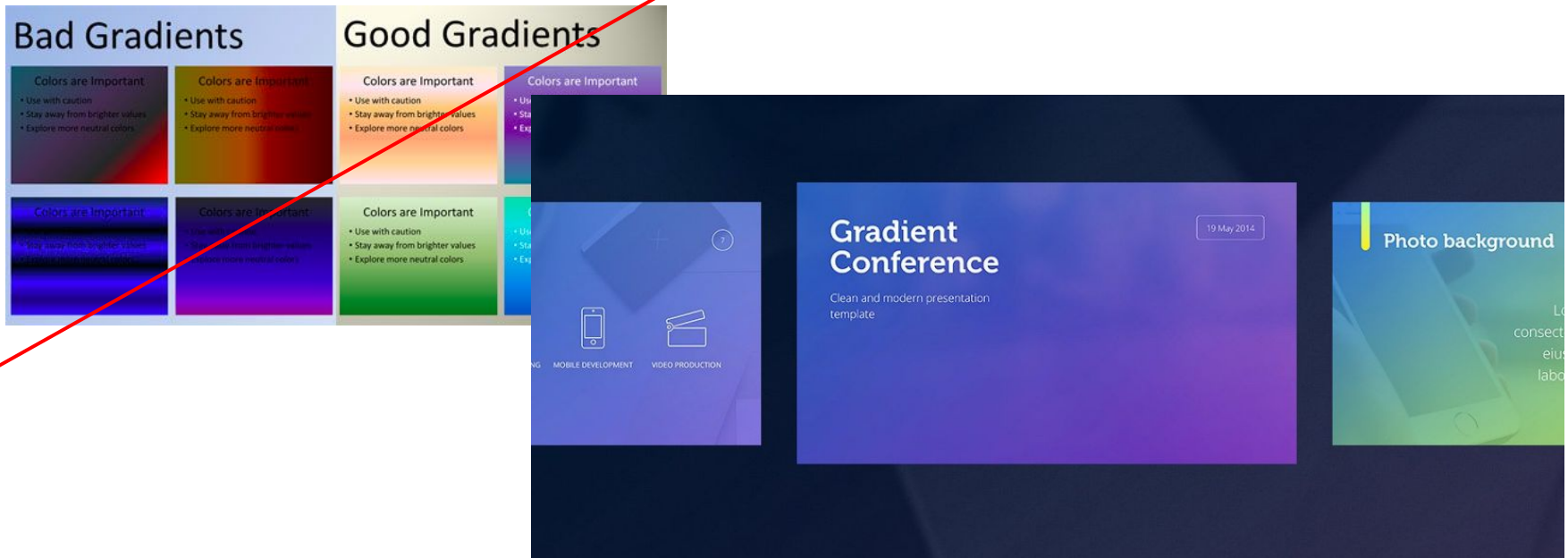
- Gradients (defaults on powerpoint)



TECHNICAL BASICS

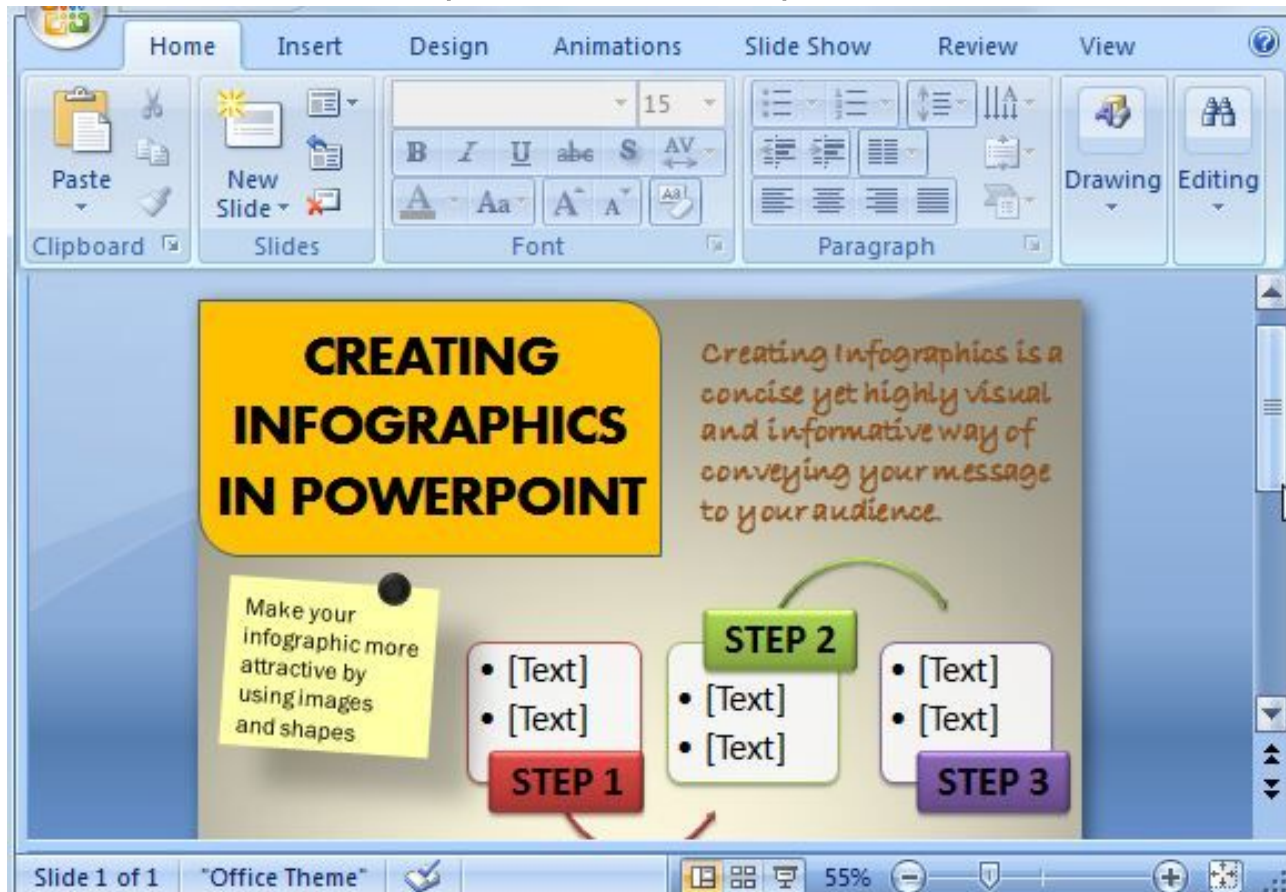
THINGS TO AVOID:

- Gradients (defaults on powerpoint)



TECHNICAL BASICS

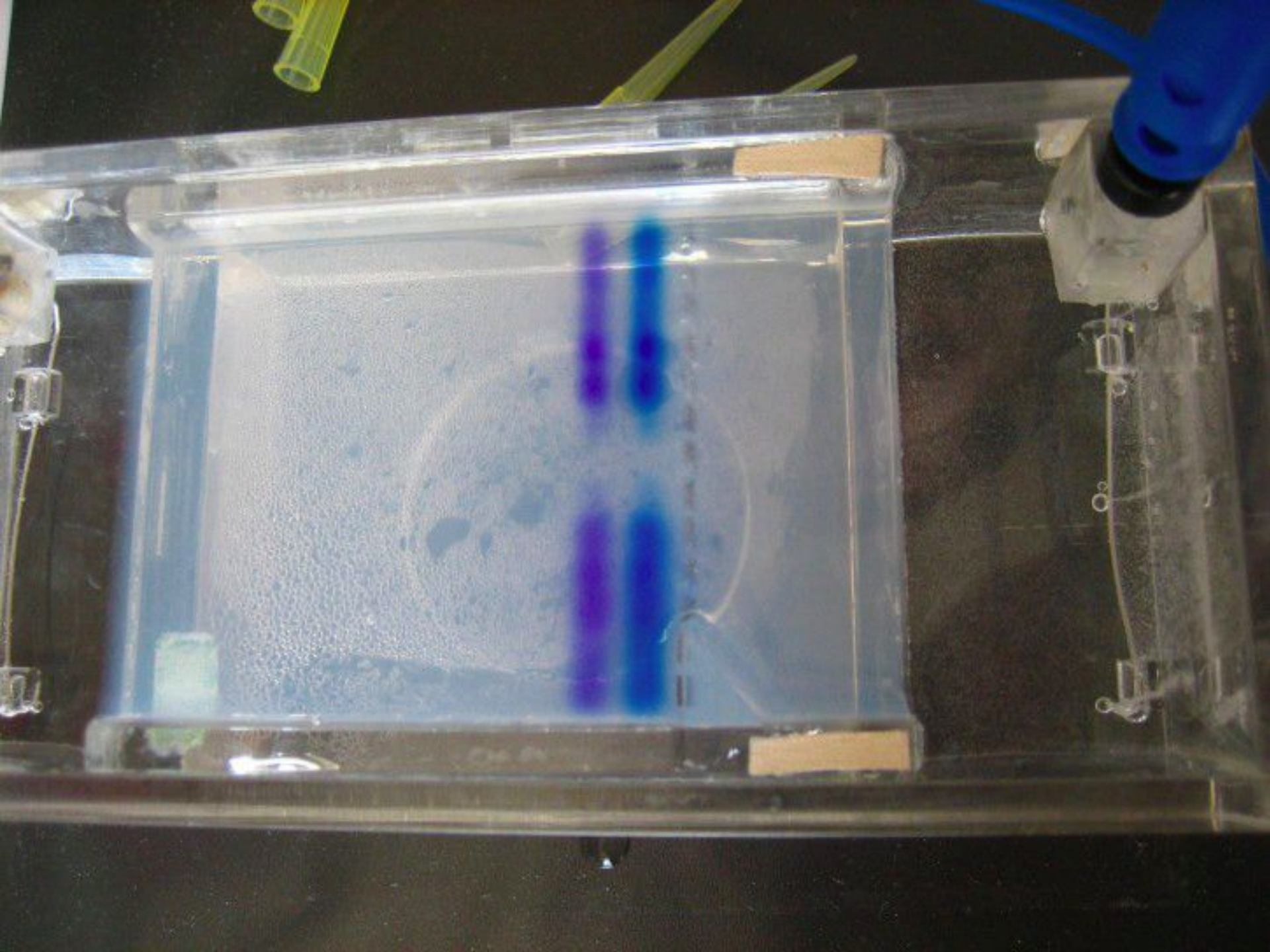
(Don't do this)

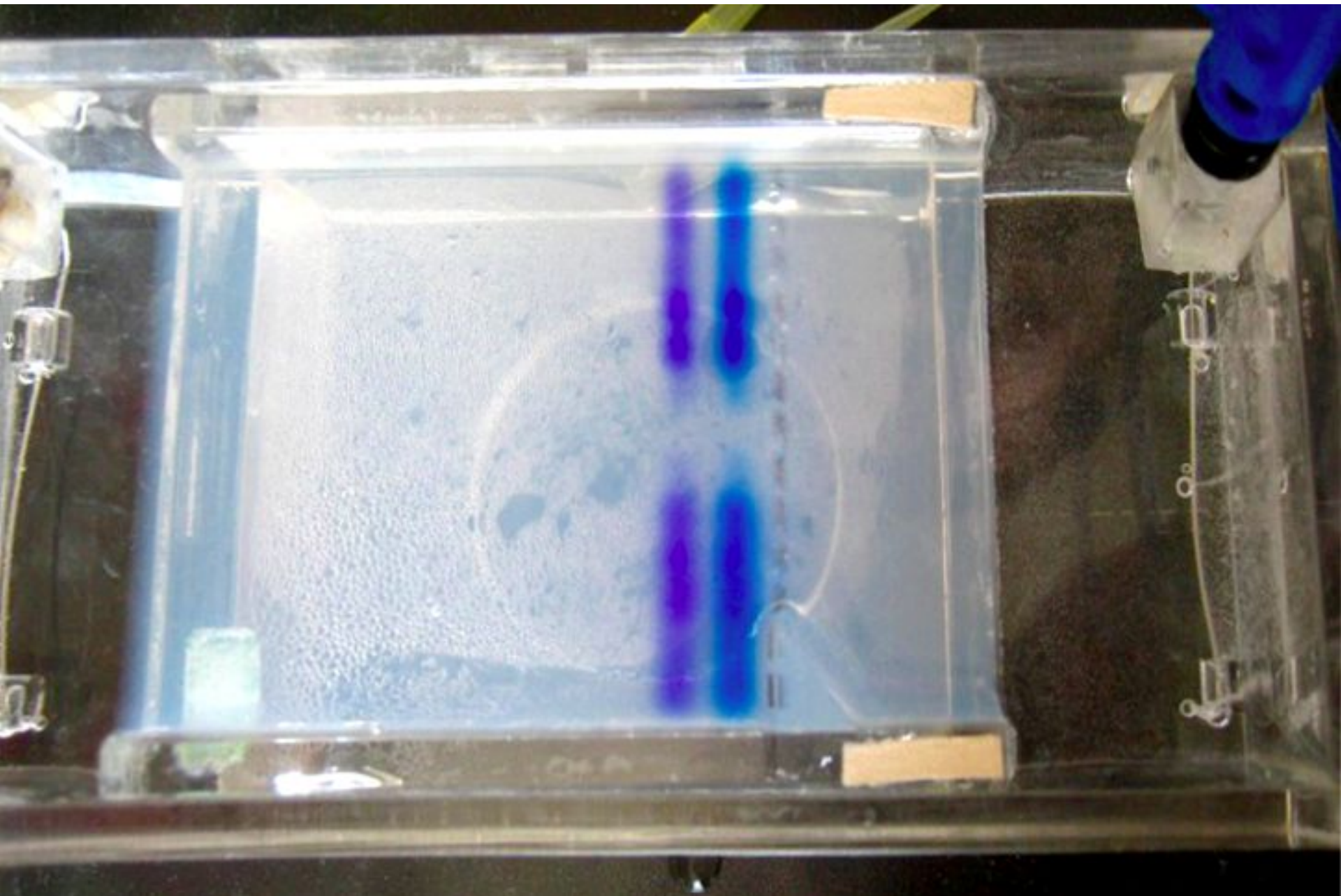


TECHNICAL BASICS

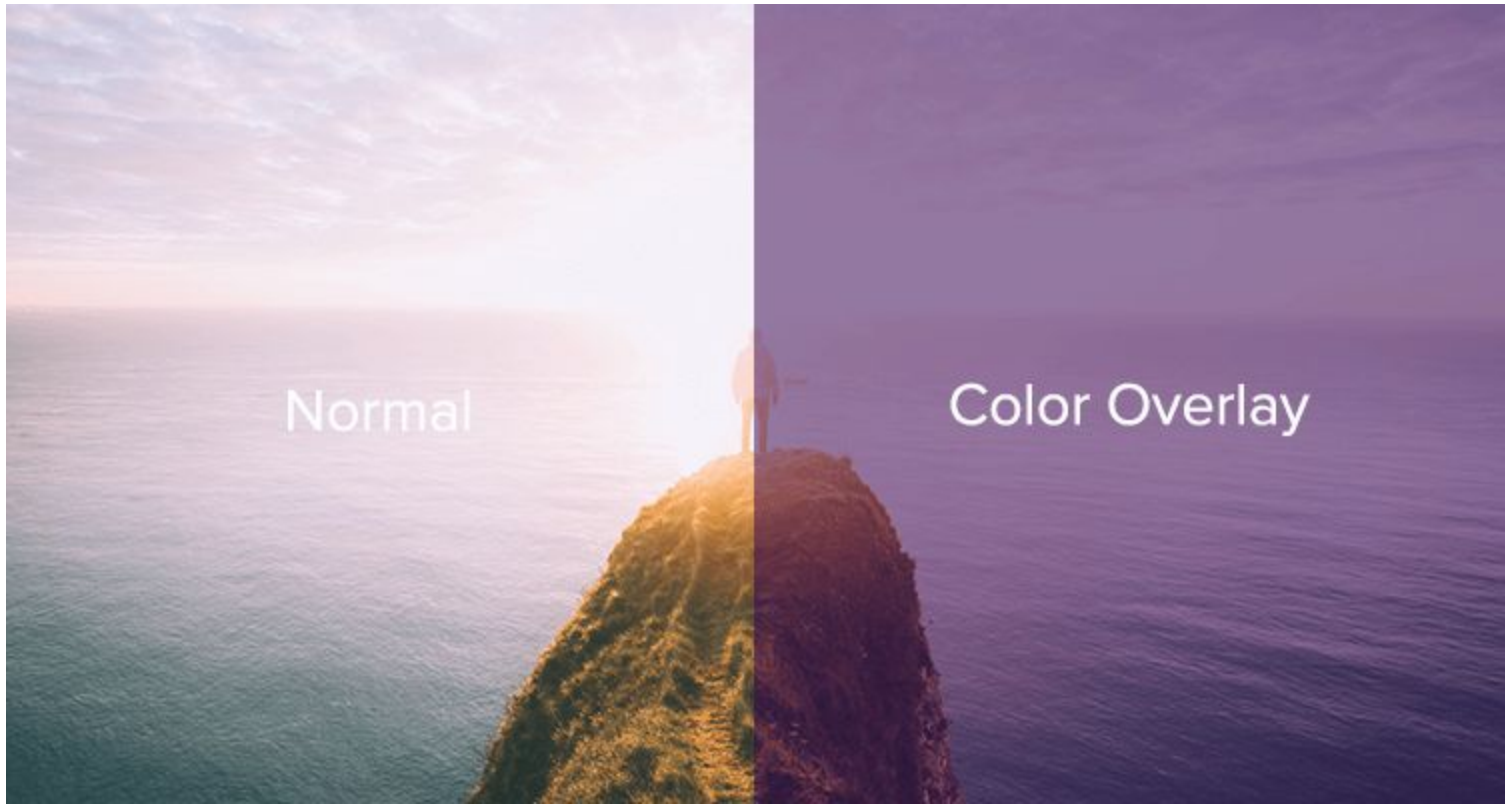
Format your photos

- Crop tightly to area of interest
- Adjust “levels” in photoshop or any image editing app
- Remove backgrounds more easily using the “magic wand” tool in photoshop
- Expand and live trace photos in Illustrator to convert to vector









Normal

Color Overlay

A dark-themed user interface for a presentation slide. The background is a blurred image of a person in a dark hoodie. The text 'The urge for good design is the same as the urge to go on living.' is centered in white. Navigation icons (back, forward, play) are visible. A vertical date indicator 'TERMINAL 5 // JUNE 16-18, 2015' is on the right. At the bottom, there are four icons (code, checkmark, diamond, square) each followed by the placeholder text 'Ut consectetur nec nibh in sagittis. In pharetra laoreet semper.'.

< >

The urge for **good design** is the same as the urge to go on living.

▶

TERMINAL 5 // JUNE 16-18, 2015

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Ut consectetur nec nibh in sagittis. In pharetra laoreet semper.

Ut consectetur nec nibh in sagittis. In pharetra laoreet semper.

Ut consectetur nec nibh in sagittis. In pharetra laoreet semper.

Ut consectetur nec nibh in sagittis. In pharetra laoreet semper.

TECHNICAL BASICS

FINAL TIPS

- Start on paper
- Test print
- Fresh eyes
- Consult with a science/medical illustrator!

An anatomical illustration of a human skull, shown in a three-quarter view from the left. The skull is rendered in a light gray, semi-transparent style, revealing the internal brain structure. A prominent yellow horizontal band is overlaid across the center of the skull, containing the text "THANK YOU!". The background is a light, textured gray.

THANK YOU!



Giveaway

(one free customized science graphic)

Email: aoki@anatomize.com

Subject: NNLM Webinar