PICTURE THIS: TRANSLATING RESEARCH INTO VISUALS FOR REPRODUCTIVE AND ENDOCRINE PHYSIOLOGY

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Abstract

Visuals play an important role in the healthcare field; students learning anatomy and physiology, patient education materials, and public infographics all rely on the effective communication of textual material in graphic form. The goal of this thesis is to contribute visual material that takes the form of signaling pathways and comparison of different disorder states as material for use in the university setting. In order to produce reliable visuals, a literature review was completed.

Keywords: visuals, pathways, endocrine physiology, reproductive physiology, insulin, erection
**Figure 1:** Simplified Normal Insulin Signaling
Figure 2: Simplified Insulin Signaling in Pregnancy, Gestational Diabetes Mellitus
**Figure 3:** Simplified Insulin Signaling in Polycystic Ovarian Syndrome (PCOS)
Figure 4: Simplified Reflexogenic Penile Erection Signaling Pathway
Figure 5: Simplified Psychogenic Penile Erection Signaling Pathway

Psychogenic erection

Hypothalamus

Cervical Nerves C1-C8
Thoracic Nerves T1-T12
Lumbar Nerves L1-L5
Sacral Nerves S1-S5
Coccygeal Nerve C9
Pudendal nerve
Dorsal nerve

T11-12
L1-2

Sympathetic Chain Ganglia
Inferior Mesenteric Plexus
Superior Hypogastric Plexus
Pelvic plexus

Damage above this point will likely:
- Prohibit psychogenic erection
- Impair ejaculation

Damage below this point will likely:
- Allow psychogenic erection
- Slightly impair ejaculation

Looking at right side only*

+ Positive thoughts

PDE5 Inhibitors
- Sildenafil (Viagra)
- Tadalafil (Cialis)
- Vardenafil (Levitra)

Senses

- Negative thoughts
- Hormonal imbalance
- Nerve damage
- Vascular damage
- Systemic damage

Alcohol & Some Drugs
Figure 6: Sex Chromosome Genotypic Disorders: 5α-reductase deficiency, androgen insensitivity, Klinefelter’s Syndrome, Turner’s Syndrome
**Artist Statement**

**Introduction**

The human body is a complex culmination of systems that is constantly receiving stimuli, interpreting information, and responding. The many small-scale processes that come together to perform these actions individually consist of different parts and chemical interactions. The sheer amount of information involved in learning physiology and anatomy can be difficult to master, and when accompanying visuals are nonexistent, incomplete, or unclear, it can be even more strenuous.

I aimed to provide comprehensive diagrams for bodily processes or clinical protocols that lack one in various topics of endocrine and reproductive physiology. This may benefit professors, students, and interested members of the general public because it will allow for a more effective communication of relevant information.

While many processes are well-explored and documented, I have found some left simply as text. For those that contain visuals, some are too complicated for the level of introductory understanding. I incorporated depictions of the anatomy, cells, or pathways used to give a glimpse into what is occurring so that the viewers are not struggling to contextualize the text.

As a current student studying both physiology and art, I have seen the impact that effective visuals can have not only in aiding the professor in presenting the information to their students, but also the manner in which students can interact with the information after leaving lecture. In
addition, I hoped to not only contribute to the physiology field but also to build on the deliberate use of art forms to share scientific information. Using various principles of art—including those of composition, color theory, contrast, balance, etc.—I created six pieces that aim to educate in an aesthetically pleasing manner.

**Research:**

**Endocrine Physiology:**

**Insulin Signaling: Normal, Pregnancy & Gestational Diabetes Mellitus, and Polycystic Ovarian Syndrome**

Insulin is a peptide hormone that is released in response to high concentrations of blood glucose. It signals a cell to increase glucose uptake to decrease blood glucose to maintain the original value. Increased insulin release and glucose uptake normally occurs with food intake as a source of glucose used in metabolic processes in which usable forms of energy are produced. As insulin signaling requires many proteins, diagrams often include a high volume of information—sometimes, all of which is not needed at an undergraduate level. I aimed to highlight some key steps that were relevant in the courses I took.

Normal insulin signaling produces an amplified second-messenger response to increase glucose uptake in skeletal muscle cells. This second-messenger system allows for rapid insertion of GLUT-4 protein carriers into the plasma membranes of these cells.
In pregnant women, there is a decreased amount of insulin released by pancreatic β-cells. This is not a disease state, but a common occurrence in normal, healthy pregnancies.\textsuperscript{7,10}

In Gestational Diabetes Mellitus, the mother becomes even more insulin resistant with a decreased level of insulin production by pancreatic islet β-cells. This condition naturally ceases when the fetus is delivered, but leaves the mother with a higher risk of obtaining Type 2 Diabetes.\textsuperscript{7,10}

In both pregnancy and Gestational Diabetes Mellitus, there is a decreased response by insulin binding as well. There is increased serine phosphorylation, decreased amounts of IRS-1 and decreased activation of PI3K, causing decreased translocation of the GLUT-4 protein carriers to the membrane. Since there is increased insulin resistance, the lack of response (high blood glucose) continues to utilize negative feedback signaling hyperinsulinemia to attempt to increase insulin response/glucose uptake. While initially these efforts may succeed, eventually this insulin resistance cannot be overcome, and the body will continue to have high blood glucose levels.\textsuperscript{5,7,10}

In Polycystic Ovarian Syndrome (PCOS), serine residue phosphorylation inactivates IR and IRS-1/2—components of the insulin second-messenger cascade—which will have two effects: (1) decrease the translocation of vesicles containing GLUT-4 carrier proteins to the cell membrane and (2) increase activation of P450c17/17α-hydroxylase in Theca cells. The first effect is metabolic, where GLUT-4 will allow for glucose uptake by skeletal muscle whereas the second effect is mitogenic, affecting increased androgen hormone production.\textsuperscript{10}
Reproductive Physiology

Penile Erection Signaling Pathways

Male penile erections are caused by relaxation of the smooth muscle surrounding the penile corpora cavernosa tissue. This allows for increased blood flow and tumescence. An erection can be obtained through two pathways—psychogenic and reflexogenic—both of which utilize the nervous system. However, these pathways are induced by different stimuli, propagate using different ANS division fibers, and operate at different locations.\(^1,7,10\) It is valuable to distinguish between the two mechanisms in order to clinically aid patients that may have dysfunction with one or both of these pathways. Considerable research includes textual information about the pathways and diagrams of the nerve fibers, but I was unable to find diagrams that incorporate the pathways in a manner contextualizing the whole body. In a clinical setting, the visuals could be adapted for patient education with altered labels as to convey the information relevant to them (ie. trauma vs. organic causes of erectile dysfunction, specific location of injury and its effects, etc.).

Psychogenic erections can be prompted by visual, imaginatory, auditory, olfactory, or tactile stimuli. These stimuli act by sending an electrical signal, known as an action potential, through the spinal cord from the respective sensory receptors, to the brain, and travel back down to the penis effector via the pudendal, dorsal, pelvic, and cavernous parasympathetic nerves.\(^1,7,10\)
Reflexogenic erections are be prompted by physical stimulation of the penis. This stimuli bypasses the brain and acts by sending an action potential through the spinal cord and returning back to the penis. \(^{1,7,10}\)

Erectile dysfunction, any inhibition of normal male penile erections, can be caused by a variety of disturbances including: alcohol and some drugs, psychological thoughts, or physical damage. As the spinal cord spans a large region, any damage done may have an impact on either of these pathways depending on the exact location. \(^{1,7,10}\)

**Sex Chromosome Genotypic Disorders**

Figure 8 displays normal XY-male and XX-female differentiation of reproductive structures as well as abnormal genotype disorders. Adapted from another diagram, this visual aims to include how abnormal genotype differentiation mechanisms compare to the normal pathways.

With a normal XY-male genotype, but a 5a-reductase enzyme deficiency, the individual will have normal testosterone action and internal male genitalia formation, but because of the lack of additional conversion of testosterone into DHT, the external genitalia will not form as normal XY-male genotype individuals. \(^{10}\)

With an XY genotype and androgen insensitivity, the individual will have internal male genitalia formation because of the unaffected SRY gene and testosterone production, but due to lack of
DHT effect on target tissues, external male genitalia will fail to form and the resulting external genitalia can be ambiguous or female depending on the level of insensitivity.\textsuperscript{10}

With an XXY genotype—also known as Klinefelter’s Syndrome, the individual can have internal male genitalia formation because of the unaffected SRY gene and testosterone production, but the individual is unlikely to mature sexually as a male at puberty, and may present with female external bodily characteristics. \textsuperscript{3,10}

With an XX or X genotype—also known as Turner’s Syndrome, the individual is likely to mature sexually as female at puberty, and will likely be infertile. \textsuperscript{9,10}

**Process:**

I utilized three different digital applications to create these pieces; the type of application used was chosen to best fit the needs of the image.

The first application I used (for Figures 4-5) is the Procreate app through my 4th generation iPad. This app allows me to draw with a stylus on the screen; it is useful because I can draw in layers allowing me to isolate and manipulate individual aspects as well as incorporate textual elements seamlessly.

The second application that I used (for Figure 6) is LucidChart which can be found online. This application allows me to create flowchart-like visuals which are text-based; it is useful because
there is the ability to move individual components and add new ones. Had I completed this on paper, it would have been difficult to rearrange once any information is added.

The third application that I used (for Figures 1-3) is Google Drawings which can be used within Google Docs. This allows me to create drawings using various shapes and textual elements, without having to commit to a singular design because of the ability to move around components. This application is useful in creating drawings that do not require specific free-form shapes and maintaining a consistent visual style. This may prove beneficial in physiology as the shape of many proteins is too detailed for the necessary information needed by professors and students alike, and representational shapes will suffice.

**Project as a Capstone**

This thesis serves as a capstone in Physiology because it allows me to utilize knowledge amassed from many courses and synthesize it into art pieces for other students to benefit from. I was able to recall the manner in which I and other students also learned from these graphics, and could try to alter them accordingly to best accommodate future students. Beginning with introductory physiology and anatomy, I was able to incorporate foundational material such as reflex arcs, and feedback loop notation. With upper-division cellular physiology, I referred to signaling pathways we learned for both content and visual style. With specifically reproductive and endocrine physiology upper-division electives, I was able to incorporate more specific information regarding these topics such as male reproductive physiology, human sexual development, and hormone effects.
Bibliography


### Appendices

**Appendix A: Poster**