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The Kidney: An Interactive tutorial

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The Kidney: An Interactive Tutorial

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Introduction

The intention of this thesis is to create an interactive, multi-media educational module. The subject is the form and function of the human kidney. This module is intended as an introductory overview to the physical description of the kidney, its tissues, functions, and its relationships with other major organs within the human body. The end product could be conceived of as a chapter in an encyclopedia set of similar such chapters. Target audiences could be, but are not limited to, secondary education and college undergraduate health science students, doctors' patients, family of patients, and/or caregivers of individuals with kidney related health issues. This program is intended for use in the context of an interactive educational computer station, a web-based educational site, for distance learning in a virtual classroom setting and as a CD/ROM that could be purchased outright or used as reference material from a public library.

The overarching design of the program is developed around four major premises. The first of these is the interactivity design. The interactive model is designed for return usage and accommodates familiarization with the program on the part of the user. First time usage navigation is prompted by the software. However, usage is fully interactive and allows for extensive self-direction by repeat users. The intention is to give the viewer maximum freedom of aided visual exploration. The second premise is the division of the intended subject matter into manageable domains. The subjects of the human kidney covered in the program include general orientation within the body, gross anatomy, internal structures, histology and function. A third organizational factor in the development of this program involves visual aesthetics and stylistic concerns.

The goal was not to simplify, but rather to clarify. My intention was to concentrate on the use of still, detailed, representational, volumetric renderings of structure and form. I sought to deliberately edit the visual subject matter in the virtual environment in such a way as to promote focus. Use was made of three-dimensional graphic modeling programs to emphasize structural relationships. Cross-sectional imagery from the Virtual Human project of the National Library of Medicine is used as a graphic corollary to my own illustrations to invite greater realism in the viewer's experience of the subject. A final concern in the development of this program is the choice of medium. The project is conceived of as a chance to make in-depth exploration into the use of electronic art mediums. The reality of my own experience is that the development of this program has drawn from, and touched upon, virtually every aspect of my education within the Master of Fine Arts in Medical Illustration program at Rochester Institute of Technology. For me, this represents the most successful aspect of my endeavor within the program.

Main Section

Interactivity Design

The most important facet of the module is that it is a self-guided tutorial. At the root level there is a Main Menu page in a host movie. Subsequent headings yield splash pages in subordinate movies linked to the host, and function as subject menus within the subordinate movie. At every opportunity viewers are led to frames and/or screens which provide them with the choice of a subject to explore or an option to move to a different subject. First time usage navigation is organized by the software. By simply following the interaction through the Forward buttons, the computer program will guide them step-by-step through the tutorial and take them to summary pages for each subheading where the information is gathered concisely for examination. The Back button will allow the user to review previously visited material, while obviating previously encountered initial steps in the sequence of inter-activity. The idea here is to allow the user to focus on the materials acquired through the interactivity once they have been encountered, while at the same time avoiding unnecessary repetitions in the process.

An aspect of the return navigation is that there are shortcuts to the summary pages found in the introductory splash page for each section. In addition to the Forward button and Back button, there are a Previous button and a Next button. The Previous button will return to the subject menu for that section. The Next button will jump between logical subdivisions within the subordinate movie. On every page is

a Main button, which allows the user to return to the host movie to further navigate between major headings. In addition there is always a Quit button available to allow ready exit from the program. The Quit button leads to an End page. The End page, while showing credits for the program, also allows for a return to the main menu if desired. Given this system of buttons, a return usage viewer can discretely navigate to areas of particular interest.

A further supporting aspect of the interactivity is that significant areas of the screen are subject to rollovers, to give visual hints or clues to the viewer that there are interactive directions available to them. Most of the actual learning information is yielded to the user after engaging in a "clickable" interactive aspect of the screen. The underlying premise is to engage the user in a series of visual examinations and responses to the material.

With the assistance of this program, the viewer should develop an imaginative, yet realistic, sense of where the kidney is within the larger body, how it is oriented in relation to the axial skeleton, and how it is situated in relationship to the organs of the abdominal cavity. Ideally, the user, when looking at the human body, should be able to visualize the kidney accurately. For example, an application of this learning would be an enhanced understanding of the results of diagnostic imagery such as Magnetic Resonance Imaging and x-ray that involve the kidney.

The major subheadings of this program include:

- Orientation
- Surrounding Organs
- Gross Structures
- Function
- Cross-section

Mediums

This project was conceived of from the start as a chance to make in depth use of contemporary mediums in electronic art. Original artwork from sketches was imported into Adobe PhotoShop 5.5 and worked up as layered image files to be imported into the Director 7.0 program as individual cast members displayed in the movie. The final output of this project was made as a Macromedia Director 7.0 projector for CD/ROM formatted for both Macintosh and PC. Other computer software programs used in the creation of this project include Adobe PhotoShop 5.5 and Illustrator 8.0. By far the majority of the original artwork generated for this project was created using the Adobe PhotoShop 5.5 program. However, Silicon Graphic Interface (SGI) Alias Wavefront 3-D modeling program was central to the conception of this project.

SGI Alias Wavefront was used to render a virtual kidney, its constituent structures, and blood vessels. The virtual kidney and its constituent parts, once created, was rendered to give an illusion of both a solid opaque modeling of the kidney, describing its surfaces, textures, and gross parts. A transparent, "visible" model of the kidney was also rendered. This allowed for a view of the modeled internal parts of the kidney while maintaining the outer shapes and dimensions of the opaque view. These views were necessary to create a platform within the Director program where the viewer could selectively alternate superficial aspects of the kidney with images affording a view of its internal parts. A further advantage of the SGI program was the ability to virtually rotate the model, and render a series of sequential views. The sequential views of the kidney were then imported into Director and used to create turntable animation. Use was made of the Internet to visit the National Institutes of

Health Visible Human project web-site, where cross-sectional imagery was downloaded from that site, edited in PhotoShop, and incorporated into this thesis project.

Domains

The contents of the Director movie, The Kidney: An Interactive Tutorial, were organized into five major subheadings. Each major subheading represents a separate constituent Director movie linked to and shown in a host movie as a Movie in A Window (MIAW). In the Main Menu of the host movie, the user interface presents the viewer with an arrangement of virtual folders, each with a clickable tab that opens that MIAW (Plate 1). There are five separate subject headings of the MIAWs, a) Orientation, b) Surrounding Organs, c) Gross Structures, d) Function, and e) Cross-sections. They are described as follows:

a) Orientation

The Orientation subject heading is conceived of as the initial chapter of the overall movie. This movie focuses on developing the viewers' awareness of the position of the kidney in relation to the axial skeleton of the body. Particular emphasis is placed on creating an awareness of the deviation between the coronal, sagittal, and transverse planes of the kidneys with their corresponding planes in the axial skeleton. Also highlighted are deviations from perfect symmetry exhibited between the kidneys. This was accomplished in the movie by presenting a series of interactive pages in which a rendered view of the kidneys is shown in incorrect relation to a corresponding view of the axial skeleton. A clickable icon in the page allows the viewer to correct the view.

Diagrammatic and textual information is supplied to support an understanding of the newly arrived at view of the kidney in corrected relationship to the axial skeleton.

The interactive pages present both kidneys and axial skeleton from the following perspectives: anterior view, posterior view, lateral view and superior view (Plate 2). For example, the anterior view presents the viewer with skeleton, the kidneys, and those muscular structures, which support the kidneys and create their orientation within the body. The musculo-skeletal structures are labeled accordingly. Initially the kidneys are presented as a mirrored pair with vertical orientation. User interaction prompts the viewer first to elevate the left kidney relative to the right kidney. Subsequent interaction allows the viewer to angle the orientation of the kidneys such that their superior poles are more medial relative to their interior poles. The results of this interactivity are collected in a summary page, which the user can return to after viewing other segments of the Orientation subject heading for concise review.

b) Surrounding Organs:

This subject heading is developed to show the relationship of the two kidneys with those organs of the abdominal cavity proximal to them. In order of appearance, the surrounding structures depicted in association with the kidney are: major blood vessels supplying the kidneys, the adrenal glands, the duodenum, the pancreas, the spleen, the colon, the stomach, and the liver. In the movie the viewer is presented with a rendering of the axial skeleton and kidneys. In a series of interactive pages the viewer is presented with an icon of an associated organ structure with a rollover state to hint at interactive

direction (Plate 3). Clicking on the icon causes the organ in question to appear in the illustration

provided in its correct relationship to the kidneys. A textual paragraph describes the precise correlation between the kidneys and the organ structure in question. The user may move onto a subsequent page. Having placed all of the associated organs into the rendering, the viewer is presented with a mini-menu page consisting of all the organ icons previously encountered. The viewer can selectively revisit for review the illustration for each organ, which highlights its particular relationship with the kidneys.

c) Gross Structures

The Gross Structures subject heading organizes and labels constituent parts of the kidney and the segmental subdivisions of its gross form. The Gross Structure section also presents the viewer with a turntable animation allowing the user to see a virtual kidney in the round, rotating in virtual space. In this subject heading the viewer is further presented with options for viewing the kidney model in a translucent state that reveals and labels its inner structures. On entering this section of the movie, the viewer is given the choice of visiting the revolving turntable view of the kidney or either of three static views: an anterior orientation view, a posterior orientation view, or a superior orientation view.

Selection of the revolving view automatically presents the viewer with a turntable animation of the three-dimensional kidney model rotating in space. Clickable icons allow the viewer to change the turntable view from a transparent "visible" state, to the opaque view, and back. Icons present in the window allow ready selection from

among the static views. Upon selecting a static view, the user is moved to a site depicting a kidney from the corresponding orientation perspective (Plate 4).

Superficial subdivisions of the kidney surface area are automatically labeled and indicated by arrows, as are relative structures of the ureter, the renal vessels, and renal fat. Rollover states are incorporated into the labels for the particular structures. The user may highlight those structures in the illustration, by rolling over their titles in the adjacent field within the frame. A clickable icon presents the viewer with a corresponding view of the transparent kidney model. Similar labeling and identifying options are presented for the internal structures now visible within the kidney.

d) Function

The Function subject heading of the movie identifies the histological components of the kidney and their organization into structures identifiable in a dissected view of the kidney in the coronal plane. The nephron is described as the functional unit of the kidney, and animated short sequences are used to describe the organization of the nephron from its constituent parts. The sequential presentation of the parts of the nephron follows the function pathway of the nephron. Presented first is the renal corpuscle, and identified in order are: the afferent arteriole, the arterial pole, the Bowman's capsule, the glomerulus, the filtrate, the urinary space and the urinary pole, the proximal convoluted tubule, and the efferent arteriole. The renal corpuscle is described as the site of filtration of the blood (Plate 5). Next identified are the proximal convoluted tubule and adjacent capillary bed, the loop of Henle, and the distal convoluted tubule and collecting tubule. Each segment of the nephron is identified as a site for the reabsorption of water, sodium and calcium, and urea. Percentages of the

original amount of filtrate that are passed on for excretion from each section of the nephron are noted.

e) Cross-sections

The Cross-sections subject heading of the movie presents the viewer with one interactive frame encompassing a slider bar in association with a rendering of the kidneys. The kidneys are depicted in their relationship to the axial skeleton, using a view previously encountered in the Surrounding Organs subject heading. Interaction with the slider bar produces a cross-sectional image in a neighboring area of the frame. In addition, a small icon depicting a three-quarters profile view of the human torso exhibits a transverse plane that moves in coordination with the positions of the slider bar to give a further reference to the viewer for the orientation of the cross-section images (Plate 6).

The cross-sectional images represent photographic transverse sections of the actual human body. When the user calls a cross-section image to appear in its image window by activating the slider bar, the cross-sectional image can be explored with the mouse to produce rollover states. Putting the mouse over various structures seen in the cross-section images will highlight those structures and produce identifying text below the image window. The Cross-section subheading materials are included to provide the viewer with another reference point for understanding the relative position of the kidneys within the body. This may ultimately aid the viewer in the interpretation of diagnostic imagery such as Magnetic Resonance Imagery and x-ray photography.

Stylistics

The layout and stylistics of the movie are intended to aid in the organization and presentation of materials throughout the program. Colors, visual textures, and illusions of light and depth are organized as keynotes to underscore the subdivision of subject materials, and to separate user interface concepts from subject material. Most topically color-coded backgrounds are used throughout each segment to associate their contents with their subject-heading concept. This was done in an effort to facilitate the user's memory for back reference purposes, and to help establish a relationship between an organizational concept and a logical grouping of the materials presented.

Throughout the movie the interface presents different levels of depth illusion, underscored by drop shadows and visual surface textures, to frame ideas presented as visual material. The variety is designed to help the viewer separate the experience of the interface layout from the experience of the illustrated subject matter. Subdued tones and sensual textures in the interface layout support the bright, highly rendered, detailed imagery of the illustrations without conflict or confusion. An important part of my concept was to use three-dimensional modeling imagery. I felt that I needed an interface that promoted a shallow, textured, illuminated virtual depth in the layout to make for an enjoyable and comfortable transition between the interface and the information.

Conclusion

The overall success of this project for me does not lay in the particulars of the visual delineation of the subject at hand, i.e. the kidney. Indeed, this was not my original choice or conception for a thesis project. The overall success of this project for me lies in the fact that it draws upon virtually every aspect of my education within this degree program. Moreover, in doing so it draws those elements together in a way that accomplishes my goals for enrolling in the Master of Fine Arts in Medical Illustration program. First and foremost, enrollment in the Gross Anatomy course gave me a first hand experience of the kidney in situ and a familiarization with its structure organization. Drawing courses in correlation with the human gross anatomy lab allowed me to develop sketches from direct observation of the cadaver. In subsequent coursework, I was able to develop my original sketches into more fully rendered and colored imagery. Histology coursework allowed me to understand the functions and tissue structures associated with the kidney. Computer application coursework within the program allowed me to work up my imagery of the kidney and include it in design layouts. Finally, I learned to use layout designs in the context of an interactive application. As a result of my coursework in pursuit of the completion of this thesis project, my creativity and productivity have increased dramatically. I feel a strong new link between my intellectual curiosity and my ability to visualize and create formal structures.

When I entered this program I had no concept of the many possibilities for creative and commercial applications of my artistic ability. I felt mainly a nagging

uncertainty about my professional future in the visual arts. My goals in entering the program included undertaking coursework in the bio-medical field, learning the use of computer art applications, and redeveloping my background skills as a fine artist into commercially applicable skills with a view towards a career in bio-medical illustration. In accepting this subject matter for a viable thesis project, I leapt from the undertaking of a personally oriented and subjectively illustrated choice of subject matter, to a more objective footing. Now I feel a relationship towards the satisfactory fulfillment of my thesis requirements as I would feel towards the satisfactory completion of a project undertaken as a professional commercial artist. Being able to combine my interest in the sciences with my artistic abilities has been personally satisfying. The supplemental aspect of creating a piece of work, which would be used purposefully and interactively, yields a heightened sense of relevance to my artwork. As for my computer training, I now feel comfortable with the use of computer art applications and have the understanding and confidence to seek out and explore on my own computer programs which are as yet unfamiliar, but for which I can envision a need. I feel further poised to explore art applications that will open the World Wide Web to me as a commercial artist. This is all quite remarkable to me in view of the fact that upon enrolling in this degree program I had as yet never opened or operated a computer art application, and had no understanding of the Internet and the World Wide Web whatsoever.

References

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Moore, K. L. (1992). Clinically oriented anatomy, 3rd edition. Baltimore, MD: Williams & Wilkins.

Netter, F. L., et al.. (1964). The Ciba collection of medical illustrations, Vol. 6: A compilation of paintings on the kidney, ureters, and urinary bladder, depicting anatomy and embryology, physiology, pathology, pathophysiology, and clinical features and treatment of diseases. West Caldwell, NJ: CIBA Pharmaceutical Company.

National Library of Medicine's Visible Human Project web site [On-line]. Available URL: http://www.nlm.nih.gov/reseasch/visible/visible_human.html

Plate 1

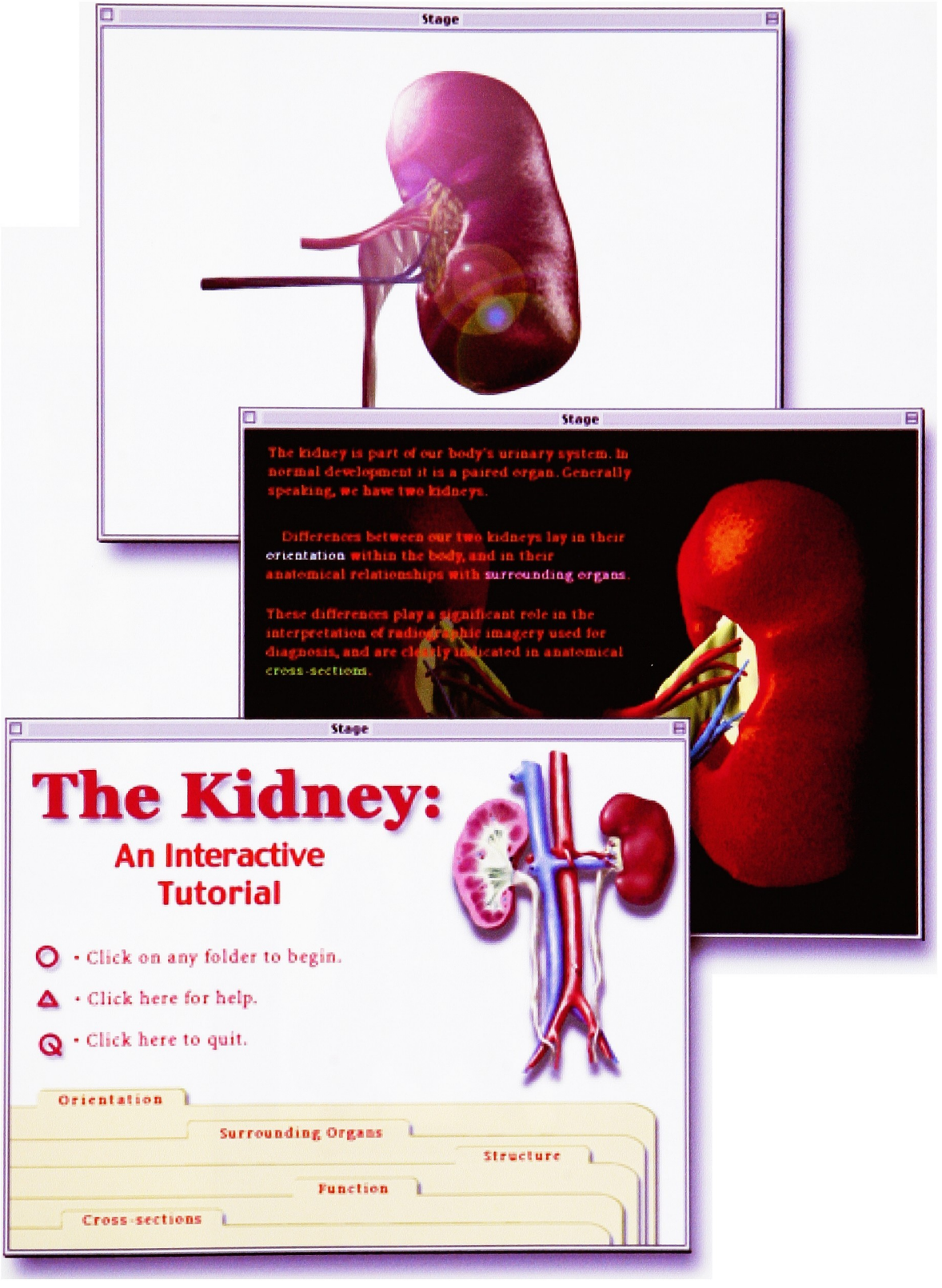

Stage
Stage
The kidney is part of our body's urinary system. In normal development it is a paired organ. Generally speaking, we have two kidneys.
Differences between our two kidneys lay in their orientation within the body, and in their anatomical relationships with surrounding organs.
These differences play a significant role in the interpretation of radiographic imagery used for diagnosis, and are clearly indicated in anatomical cross-sections.
Stage
The Kidney:
An Interactive Tutorial
• Click on any folder to begin.
• Click here for help.
• Click here to quit.
Orientation
Surrounding Organs
Structure
Function
Cross-sections

Plate 2

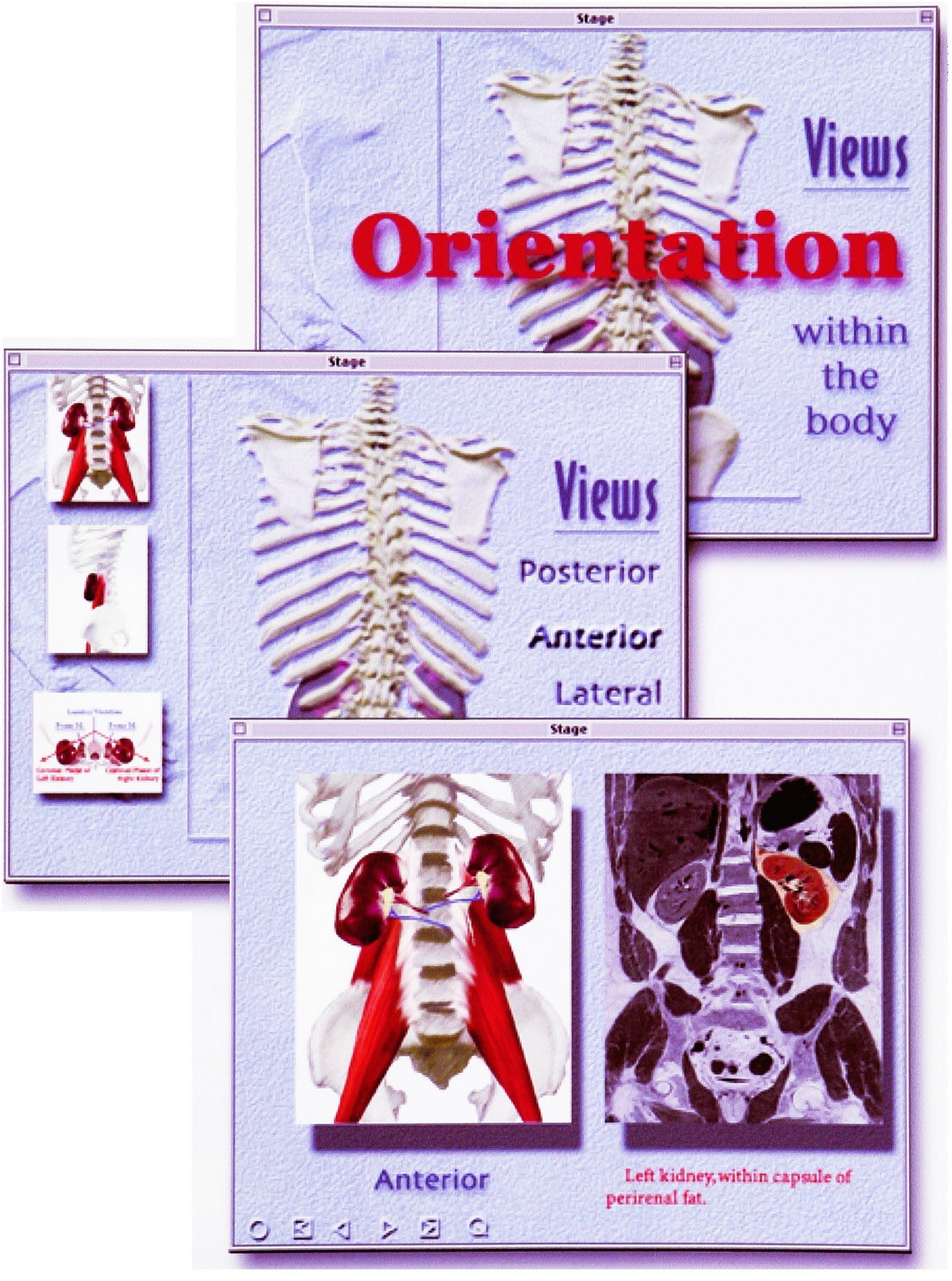

Stage
Views
Orientation
within
the
body
Stage
Views
Posterior
Anterior
Lateral
Stage
Anterior
Left kidney, within capsule of perirenal fat.

Plate 3

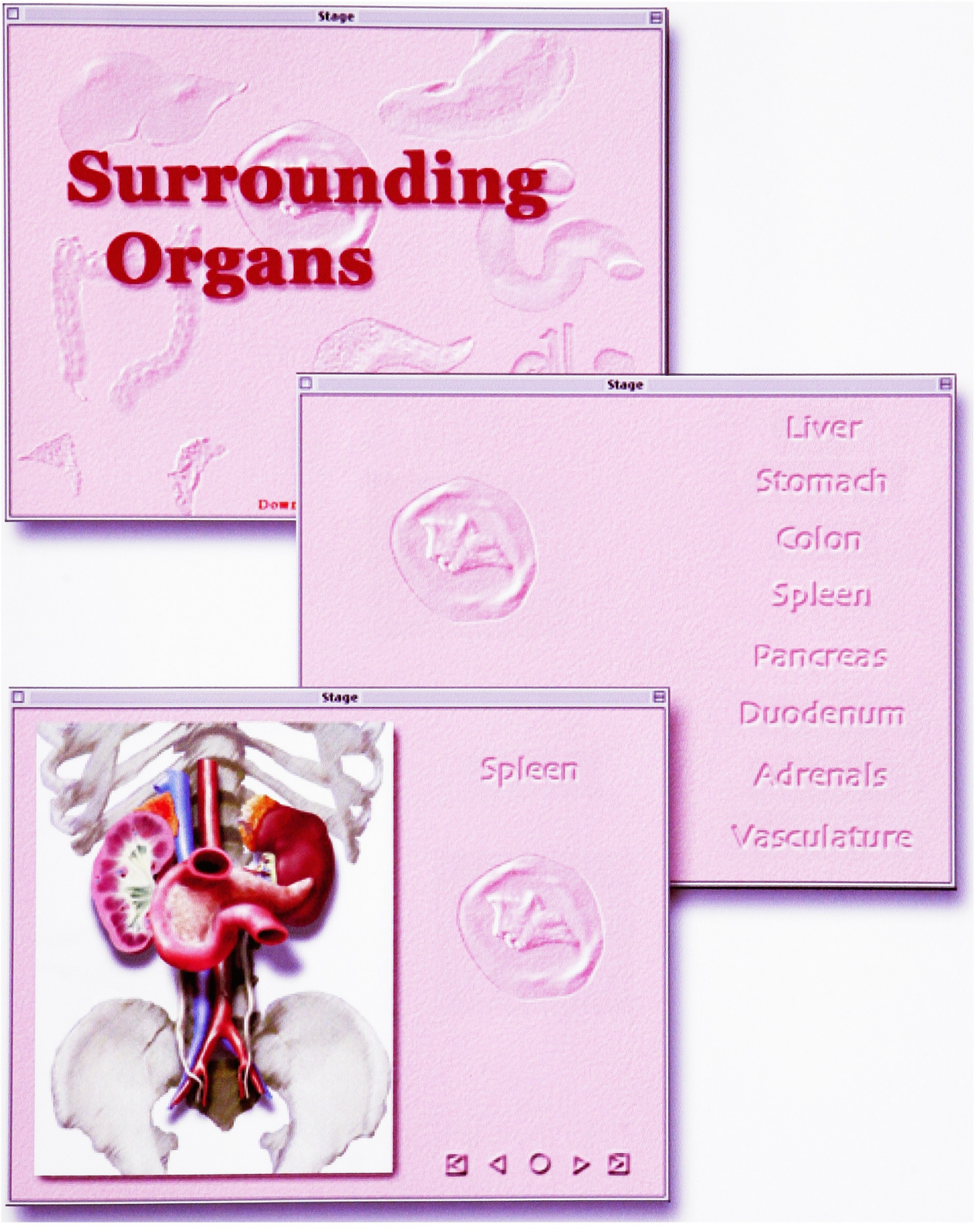

Stage
Surrounding Organs
Stage
Liver
Stomach
Colon
Spleen
Pancreas
Duodenum
Adrenals
Vasculature
Stage
Spleen

Plate 4

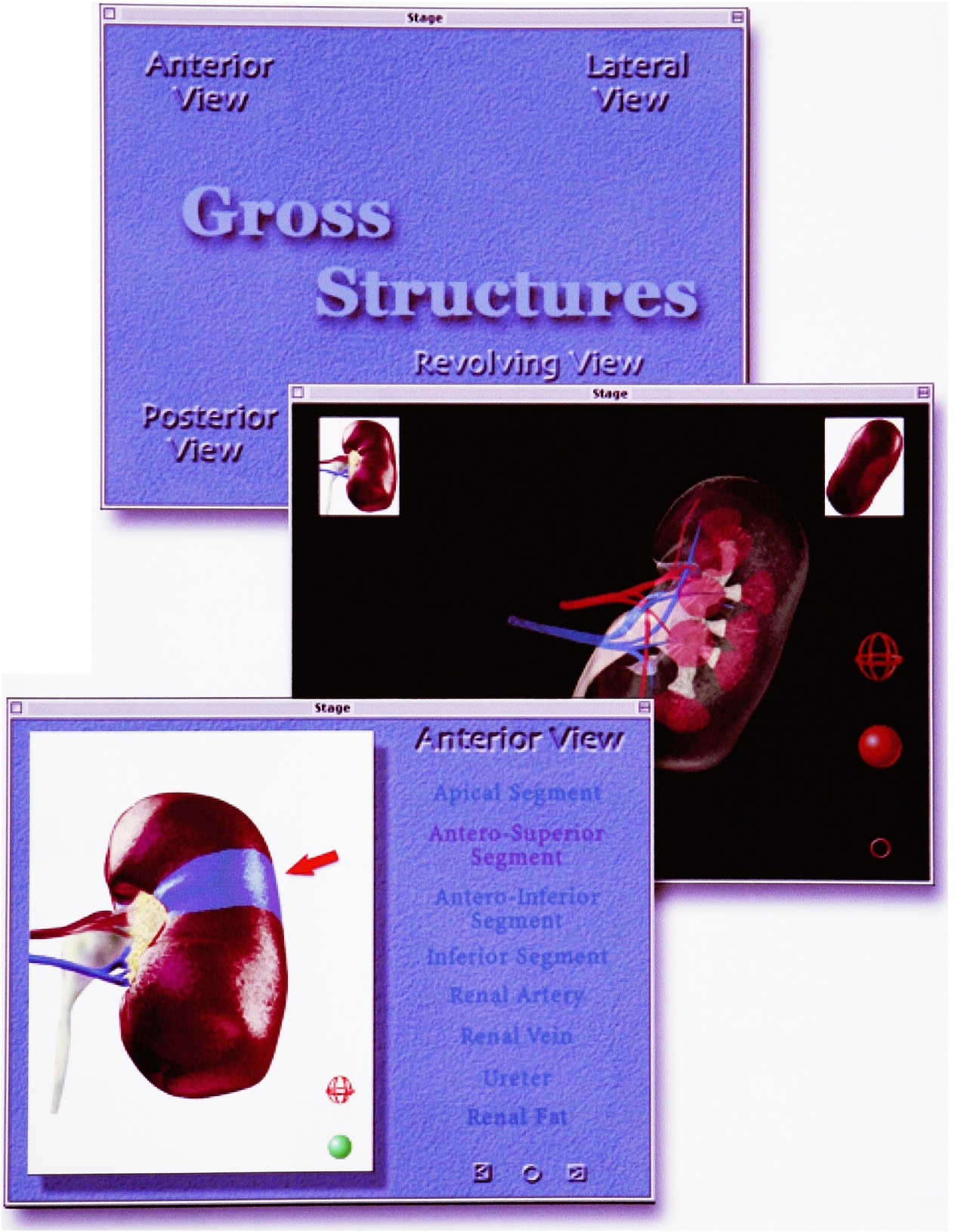

Stage
Anterior View
Lateral View
Gross Structures
Revolving View
Posterior View
Stage
Stage
Anterior View
Apical Segment
Antero-Superior Segment
Antero-Inferior Segment
Inferior Segment
Renal Artery
Renal Vein
Ureter
Renal Fat

Plate 5

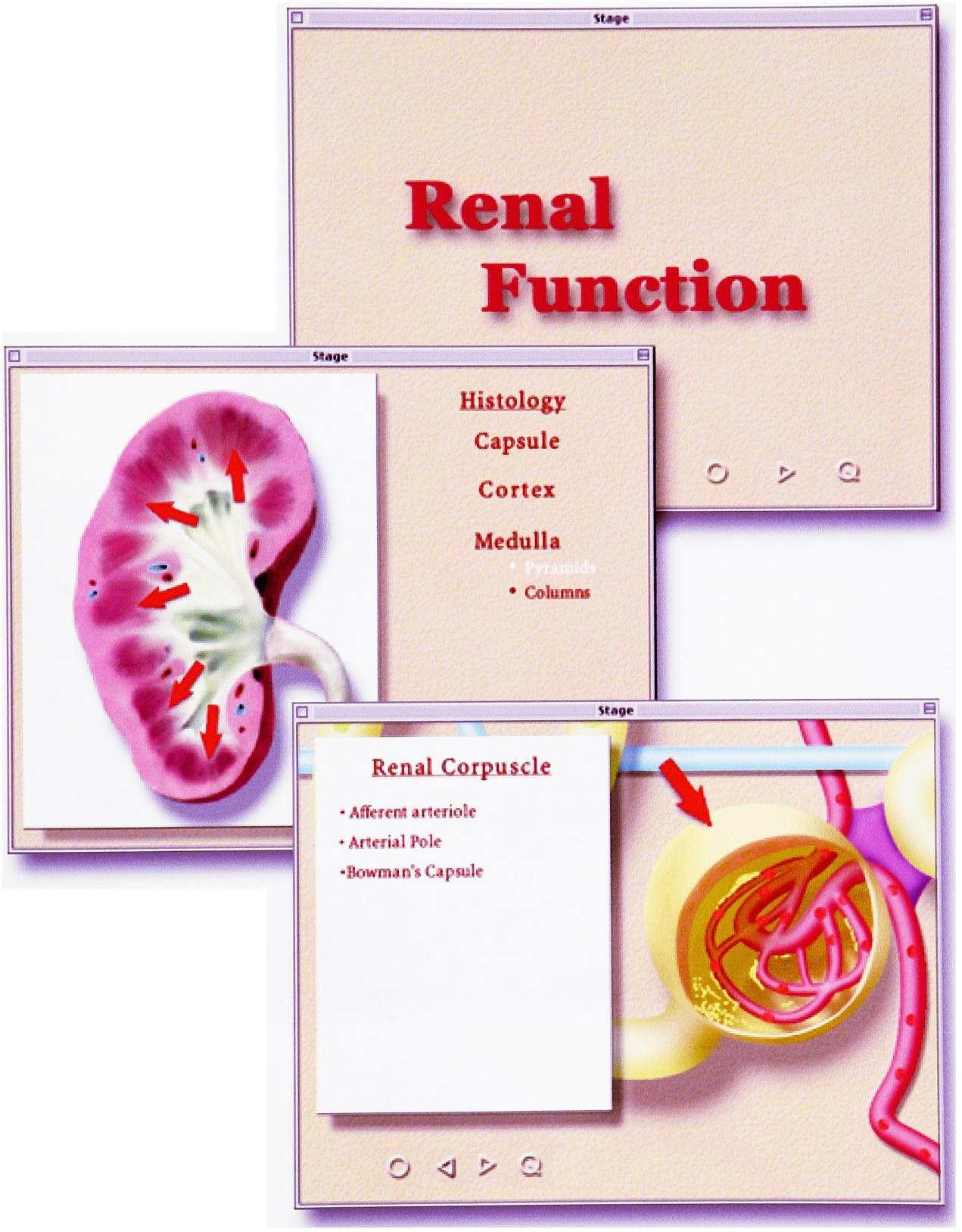
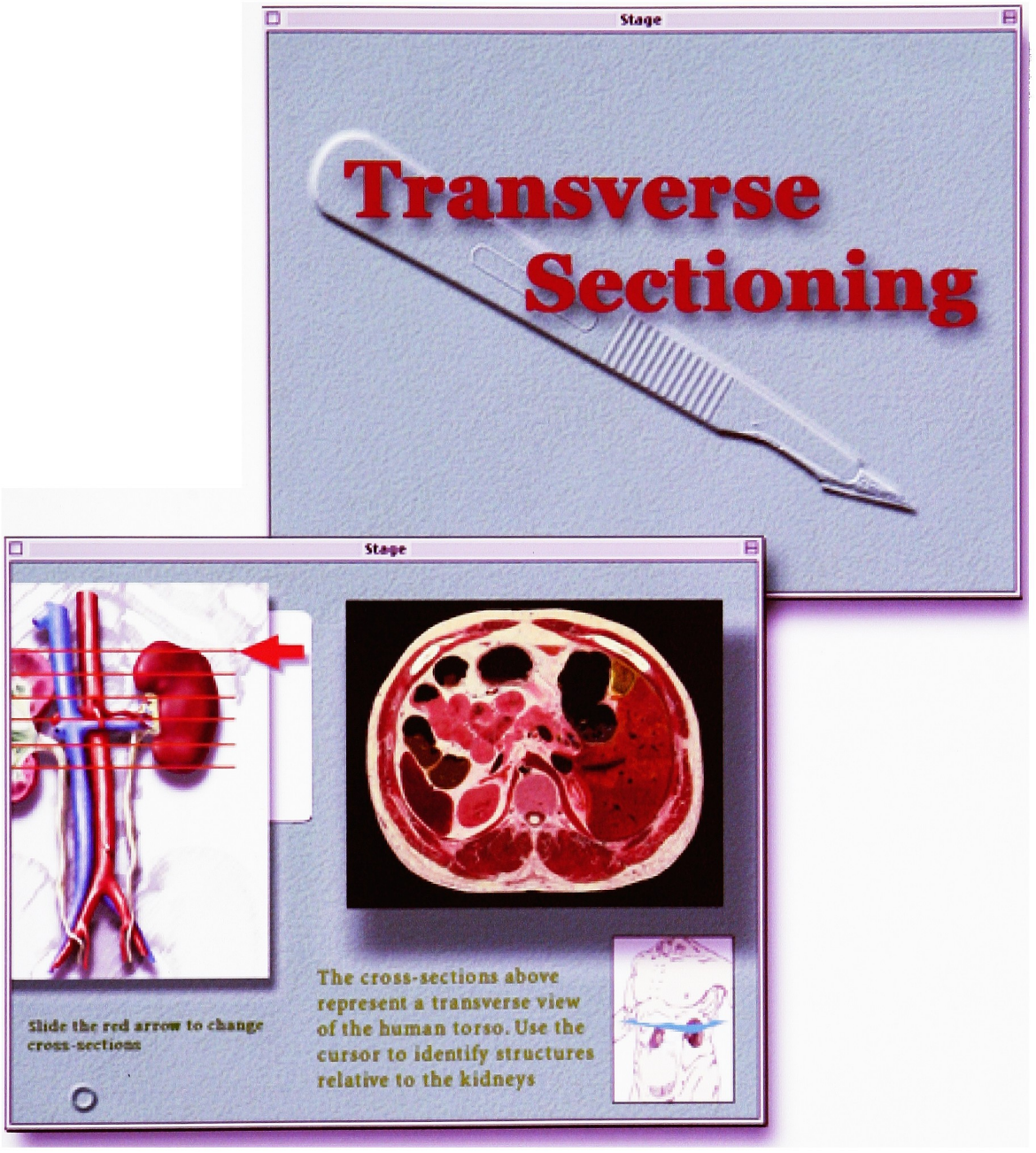

Stage
Renal
Function
Stage
Histology
Capsule
Cortex
Medulla
• Pyramids
• Columns
Stage
Renal Corpuscle
• Afferent arteriole
• Arterial Pole
•Bowman's Capsule

Plate 6


Stage
Transverse Sectioning
Stage
Slide the red arrow to change cross-sections
The cross-sections above represent a transverse view of the human torso. Use the cursor to identify structures relative to the kidneys