

3D Human Internal Organs Representation Model (Updates)

SIGGRAPH Web3D Standardization Meeting (Korea Chapter)

July 29, 2019

Myeong Won Lee (The University of Suwon)

Requirements (1)

- 3D printing and scanning
 - Interface to 3D printers for internal organs
 - Interface to 3D scanners for internal organs

3D
information
model for
3D printing



3dprint.com



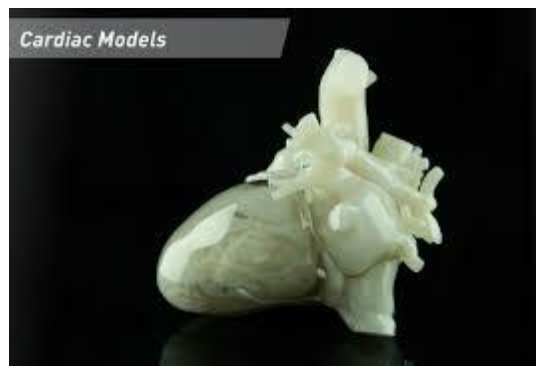
3dprintingindustry.com



pinterest.com



imedicin.wordpress.com



SIGGRAPH Web3D Standardization Meeting
3dprintingindustry.com



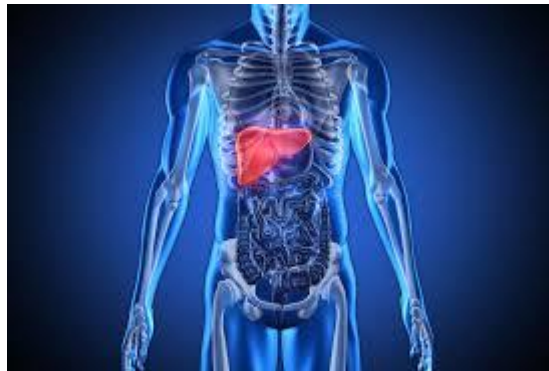
en.people.cn

Requirements (2)

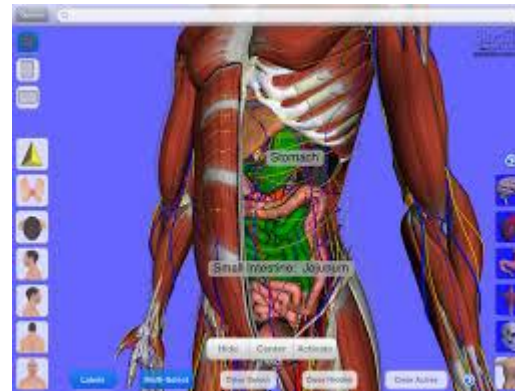
- Human health care service applications
 - Internal organs representation
 - Human health device and information service



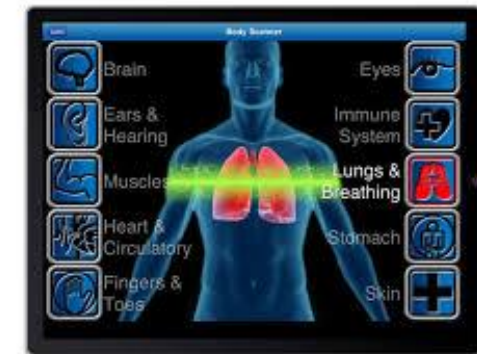
3D
information
model for
health care



cargocollective.com



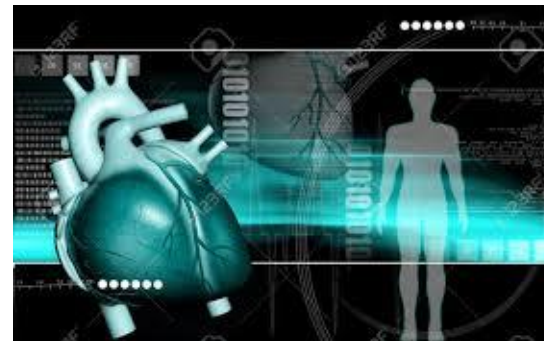
imedicalapps.com



cargocollective.com



123rf.com



123rf.com



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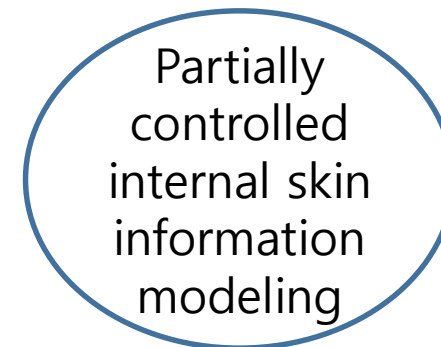
3D Digital Human Modeling (1)

- Concepts

- Provision with digital processing functionalities for an entire human body in 3D using all visual and functional information about internal organs as well as external human surface model and skeleton motion
- 3D modeling and animation technology for digital information processing that can represent shapes, properties, function, and motion for human bodies, including internal organs
- Standardized 3D digital information necessary for developing 3D medical and health care applications

3D Digital Human Modeling (2)

- Required technologies
 - Shape modeling of internal and external whole bodies in partial or whole forms using graphics technology
 - Motion modeling of internal and external whole bodies in partial or whole forms using graphics technology
 - For all visual human models, functional properties should be able to be defined and combined for shape and motion modeling of a human model



Partially
controlled
internal skin
information
modeling

Humanoid Body Related Standards

- ISO/IEC 19774 Humanoid Animation: 2006 V1.0 (IS)
- ISO/IEC 19774 Humanoid Animation – Part 1: Architecture V2.0 (FDIS)
- ISO/IEC 19774 Humanoid Animation – Part 2: Motion Capture V2.0 (FDIS)
- ISO 7250-1: 2008 Basic human body measurements for technological design – Part 1: Body measurement definitions and landmarks
- ISO/TR 7250-2: 2010 Basic human body measurements for technological design – Part 2: Statistical summaries of body measurements from national populations
- ISO 7250-3: 2015 Basic human body measurements for technological design – Part 2: Worldwide and regional design ranges for use in product standards

Standardization Topics

- Representation data model for visualizing human internal organs and their functionalities
 - Modeling data exchange format of human internal organs
 - Animation data exchange format of human internal organs
- Interface data model for representing functions of medical and health devices with human internal organ models in 3D scenes

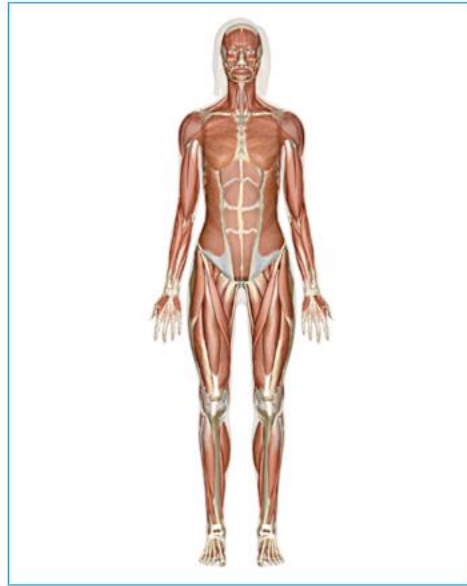
Representation Data Model for Human Internal Organs

- Modeling data model
 - Soft object representation
 - Soft object modeling
 - Landmarks
 - Information model for shape representation
- Animation data model
 - Animation methods
 - Animation parameters
 - Animation definition
 - Information model for animation representation
- Interface data model with medical and health devices

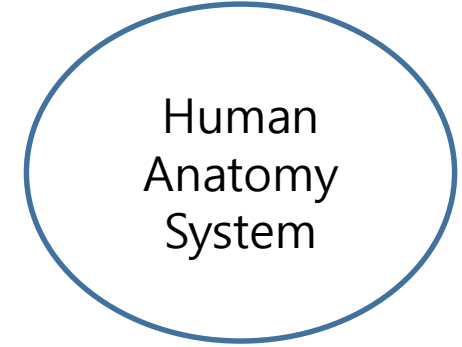
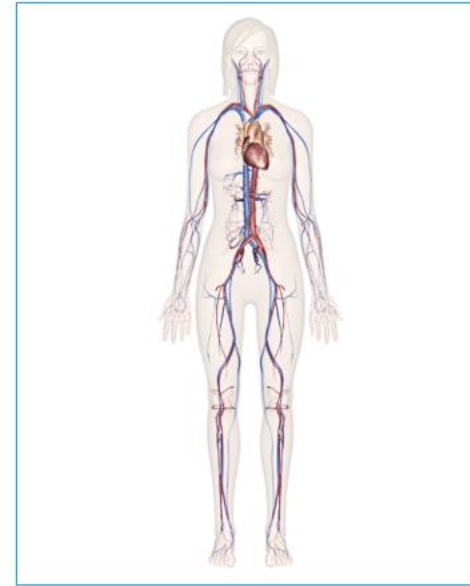
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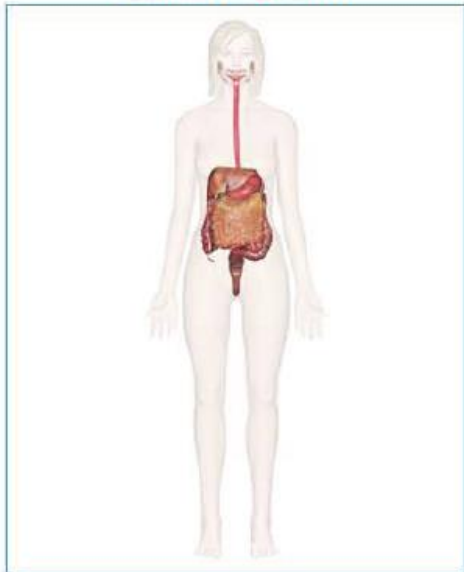
Muscular System



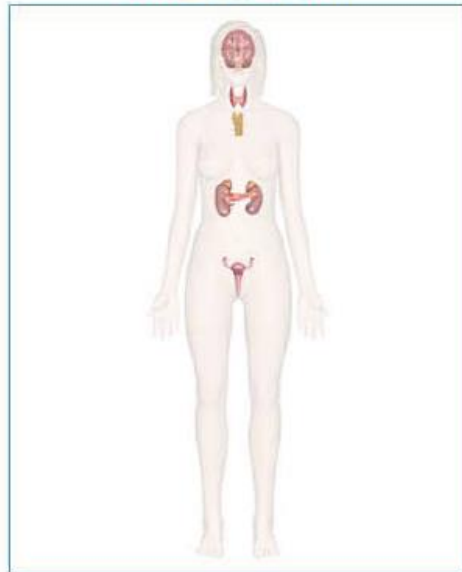
Cardiovascular System



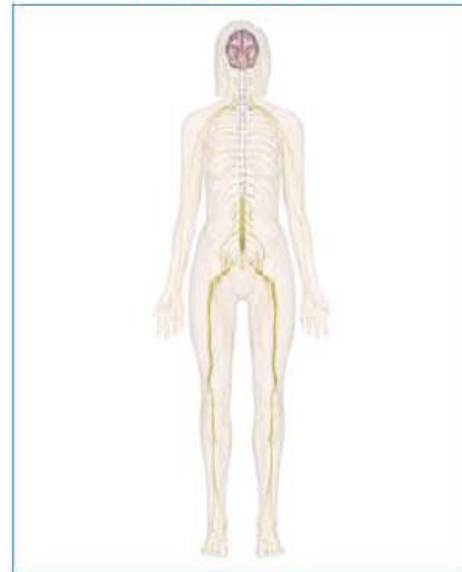
Digestive System



Endocrine System



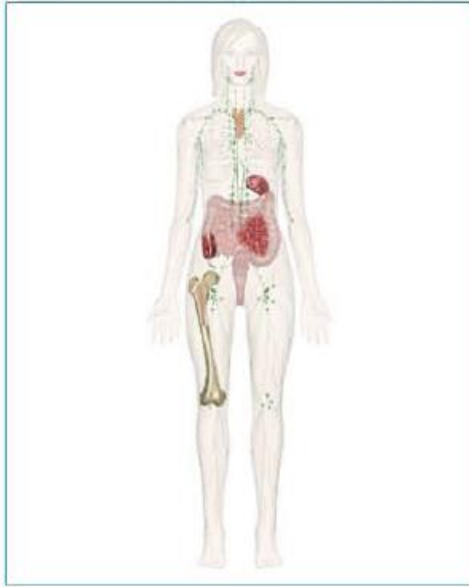
Nervous System



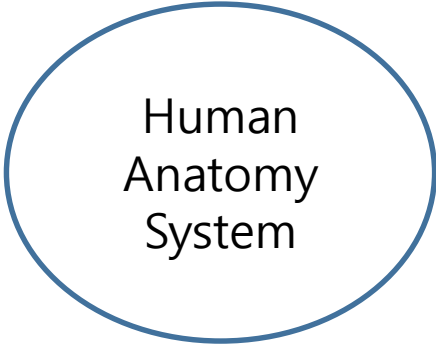
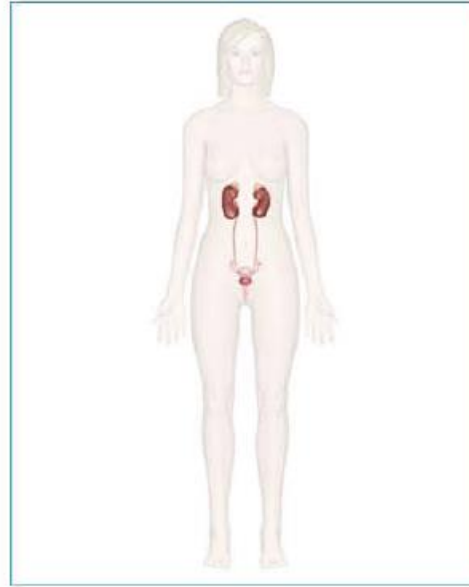
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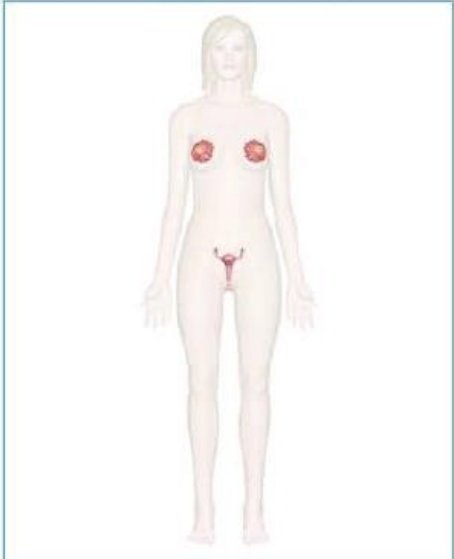
Immune / Lymphatic Systems



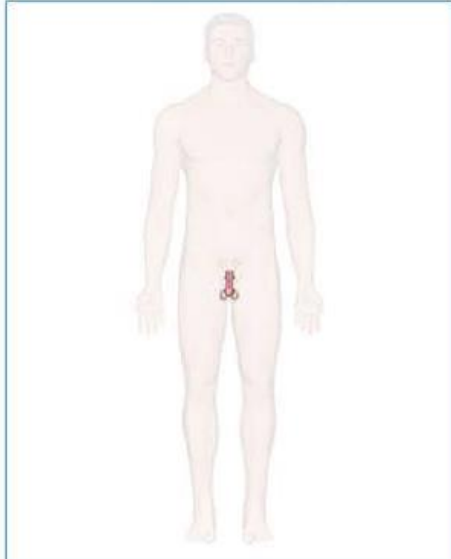
Urinary System



Female Reproductive System



Male Reproductive System

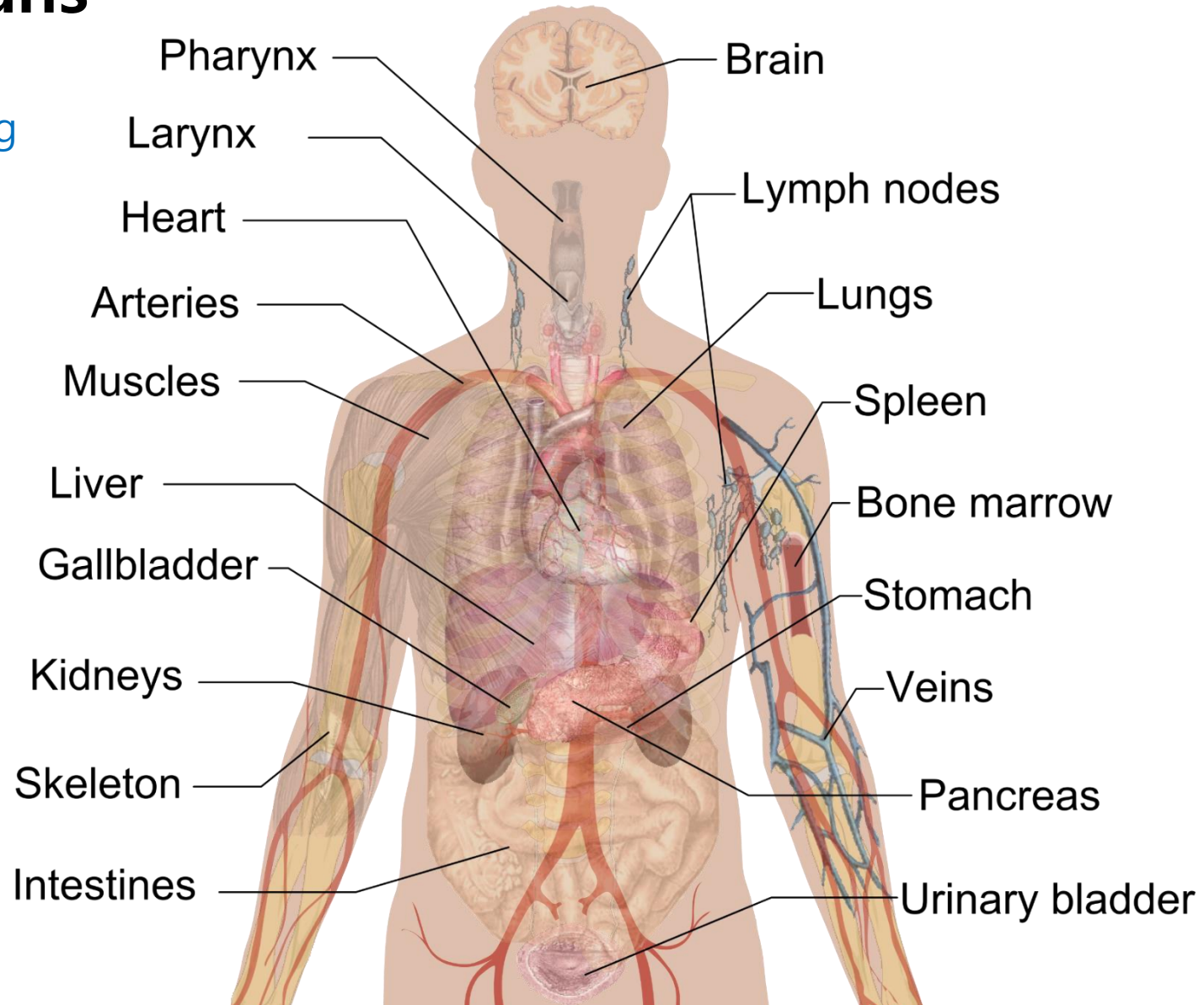


Integumentary System



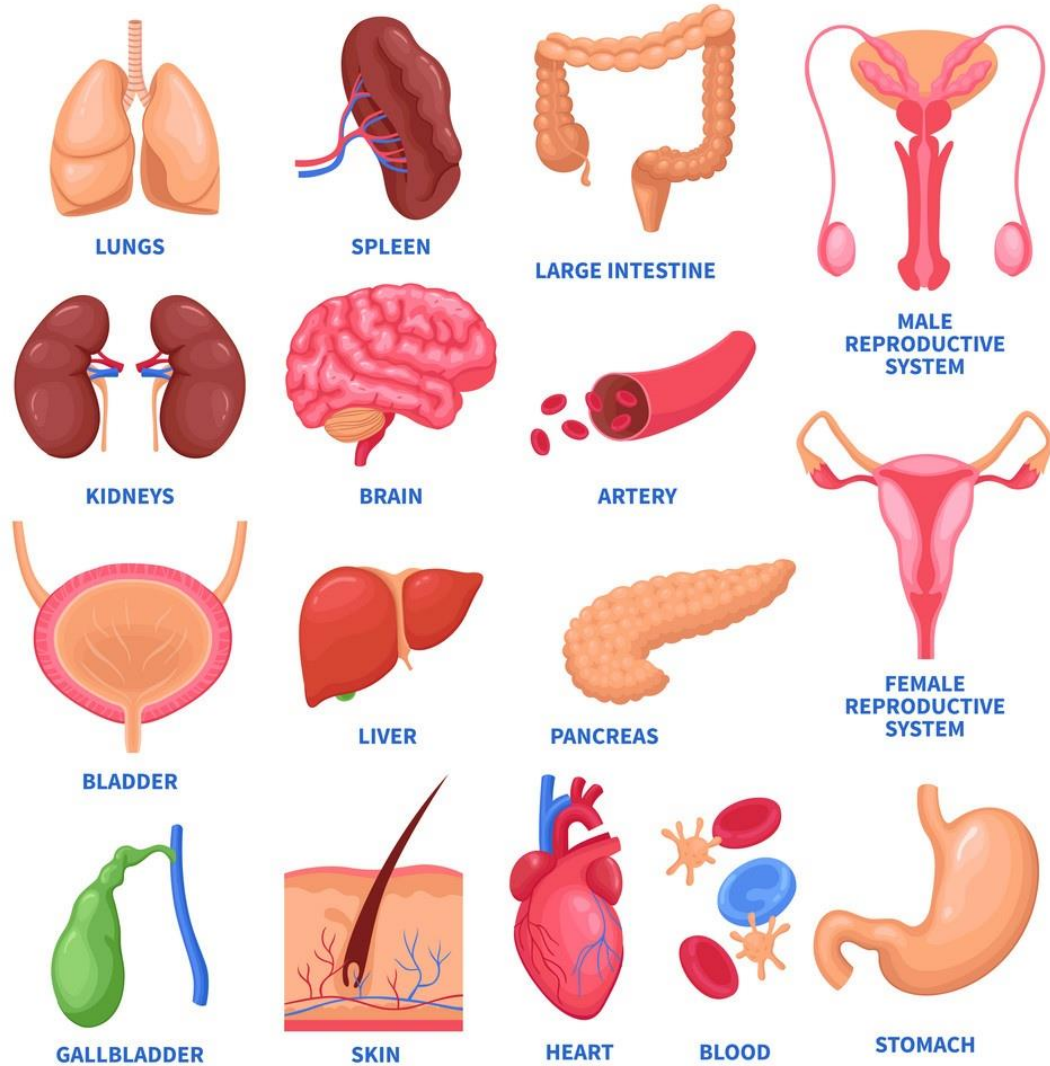
Internal Organs

commons.wikimedia.org

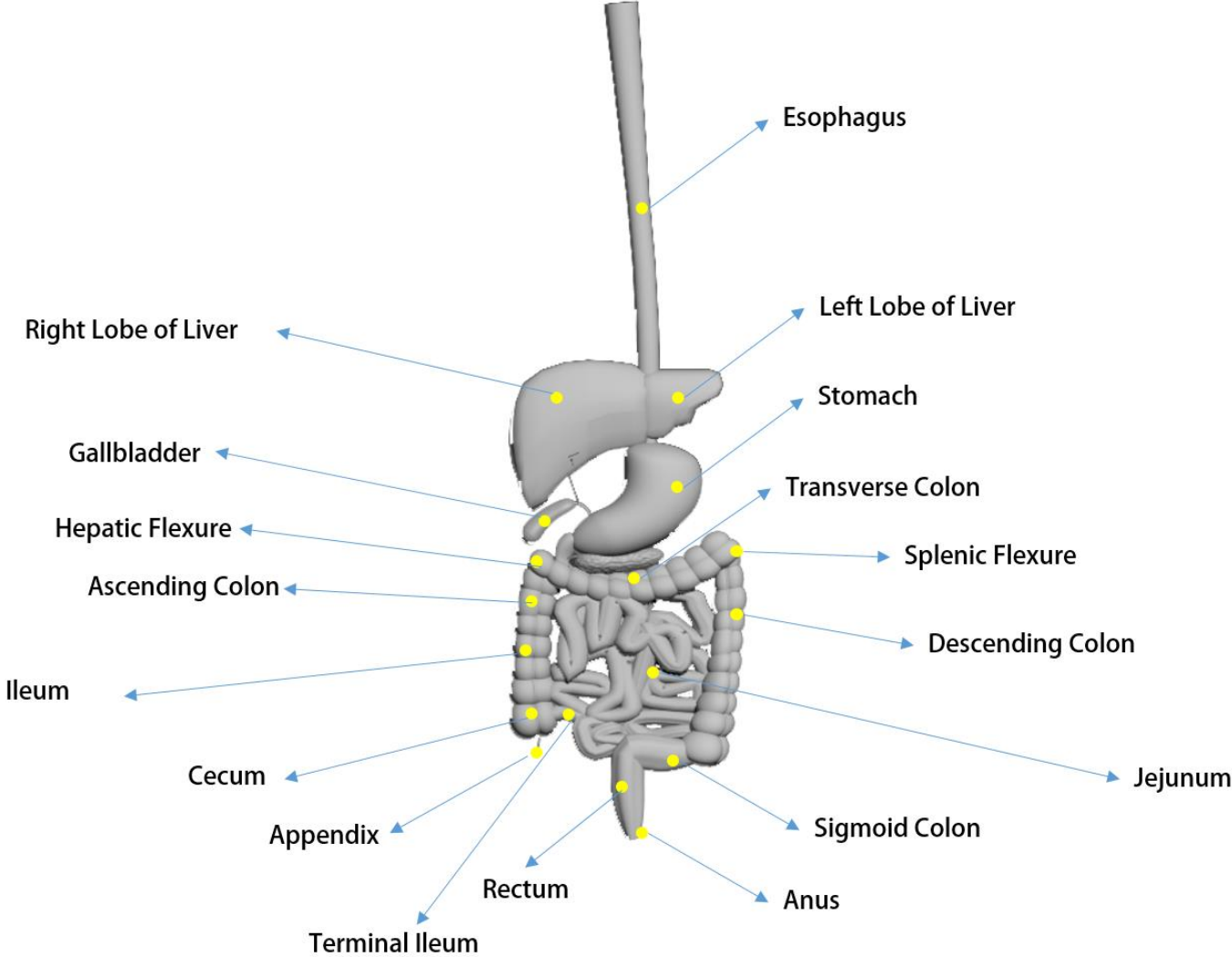


Internal Organs Set

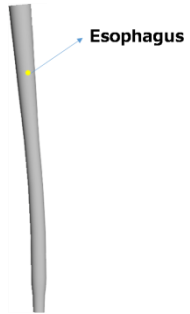
vectorStock.com



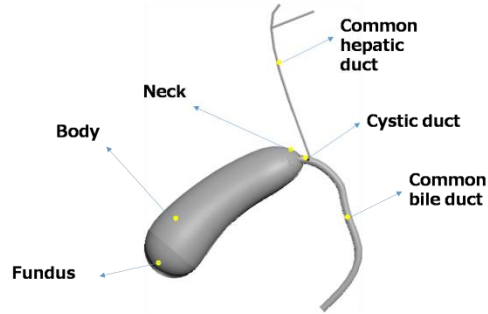
Digestive System



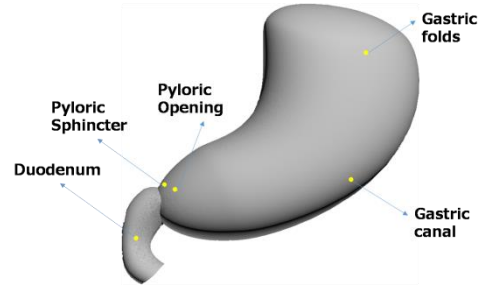
Digestive organs



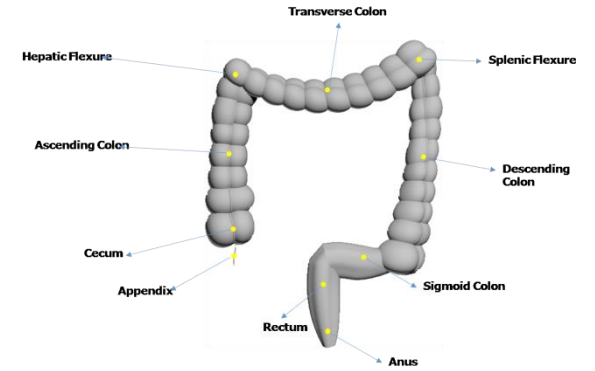
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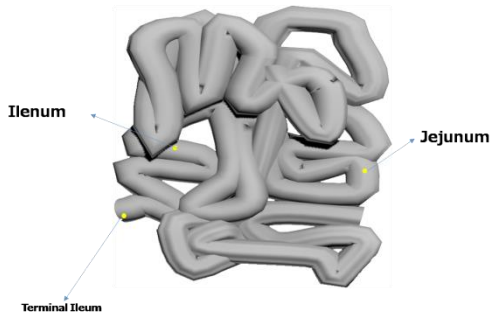
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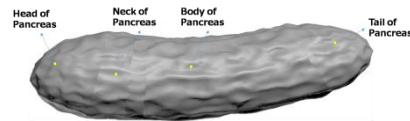
Stomach



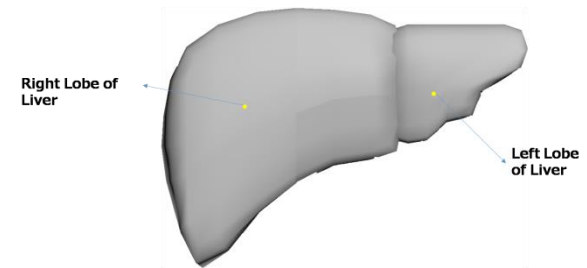
Large intestine



Small intestine



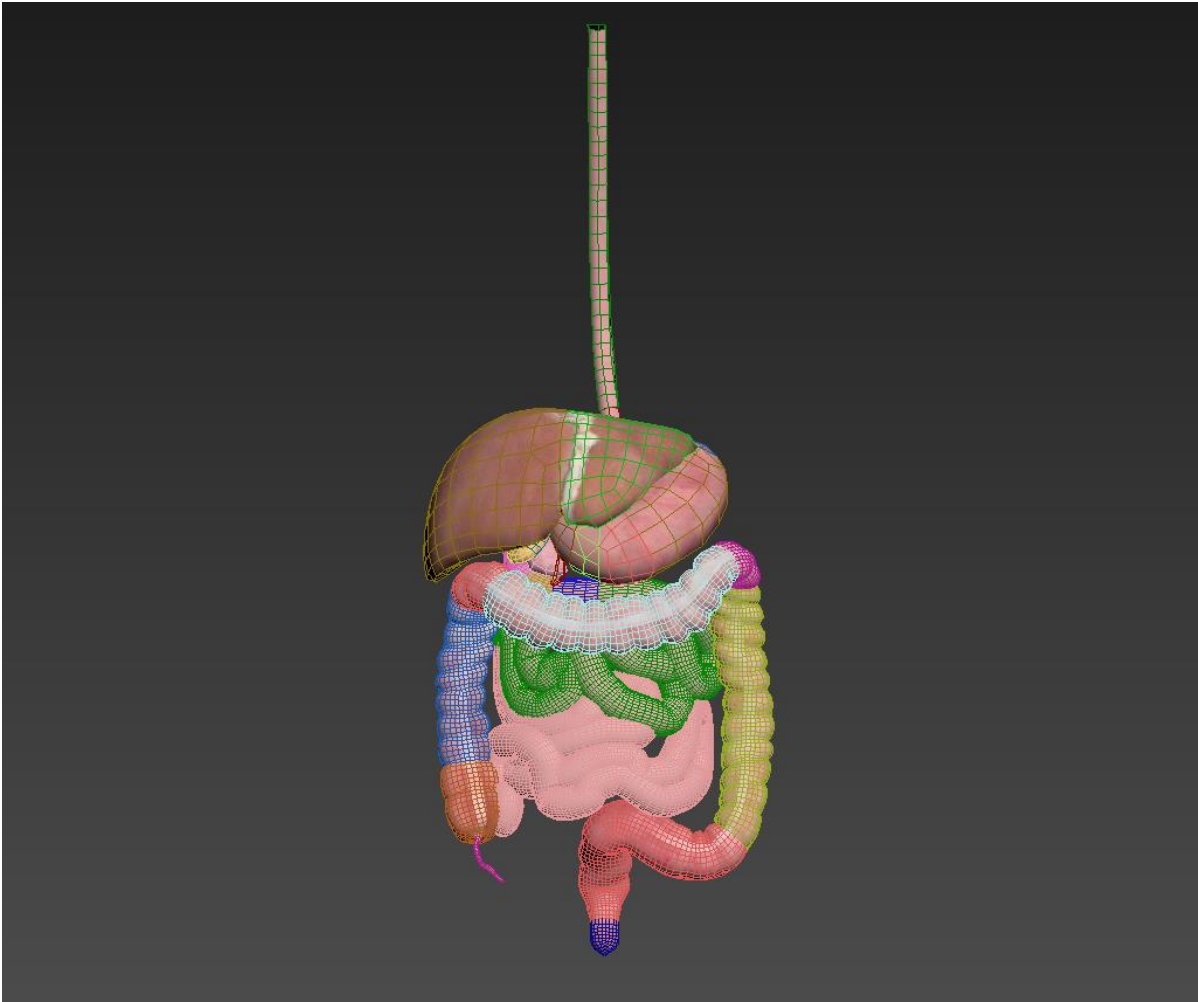
Pancreas



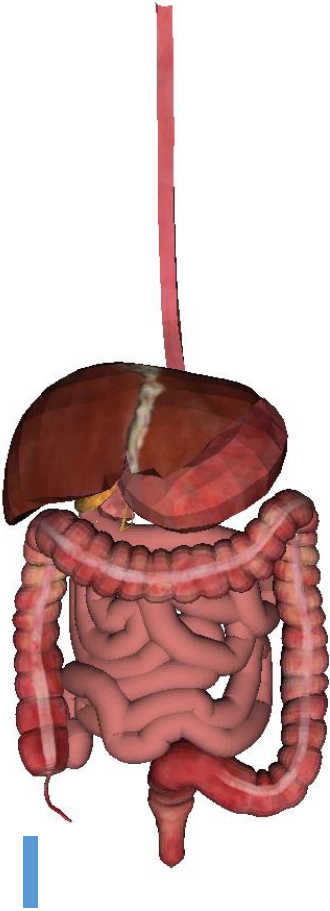
Liver

Digestive System Modeling

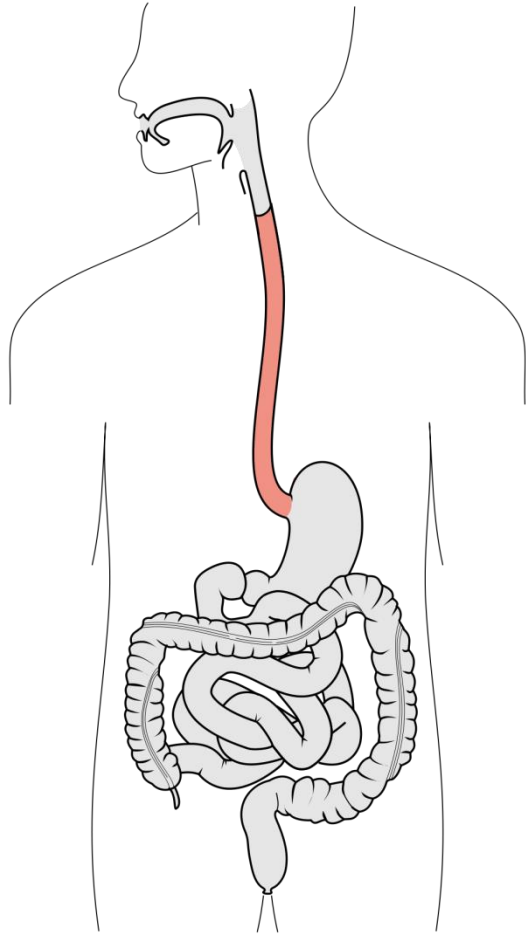
3ds Max Viewport Shot



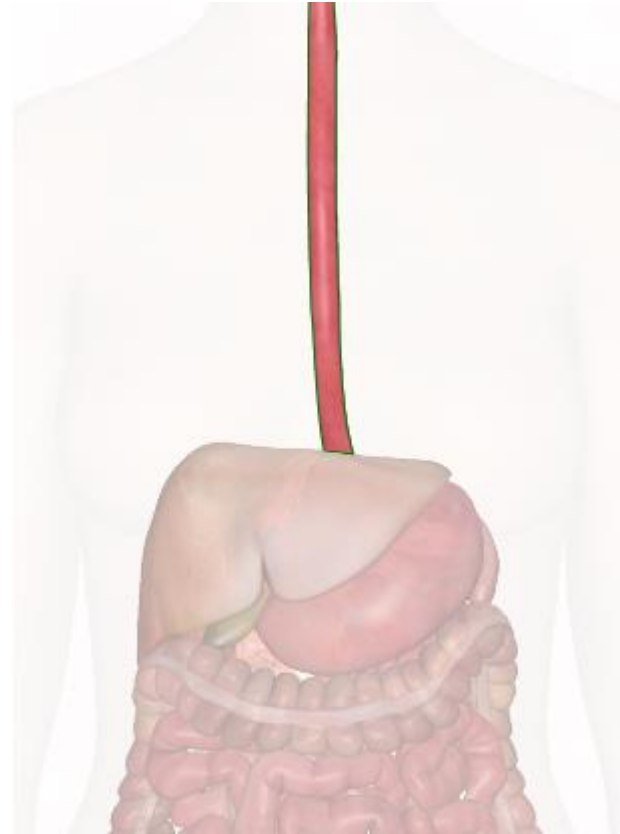
x3d Viewer



Digestive System - Esophagus



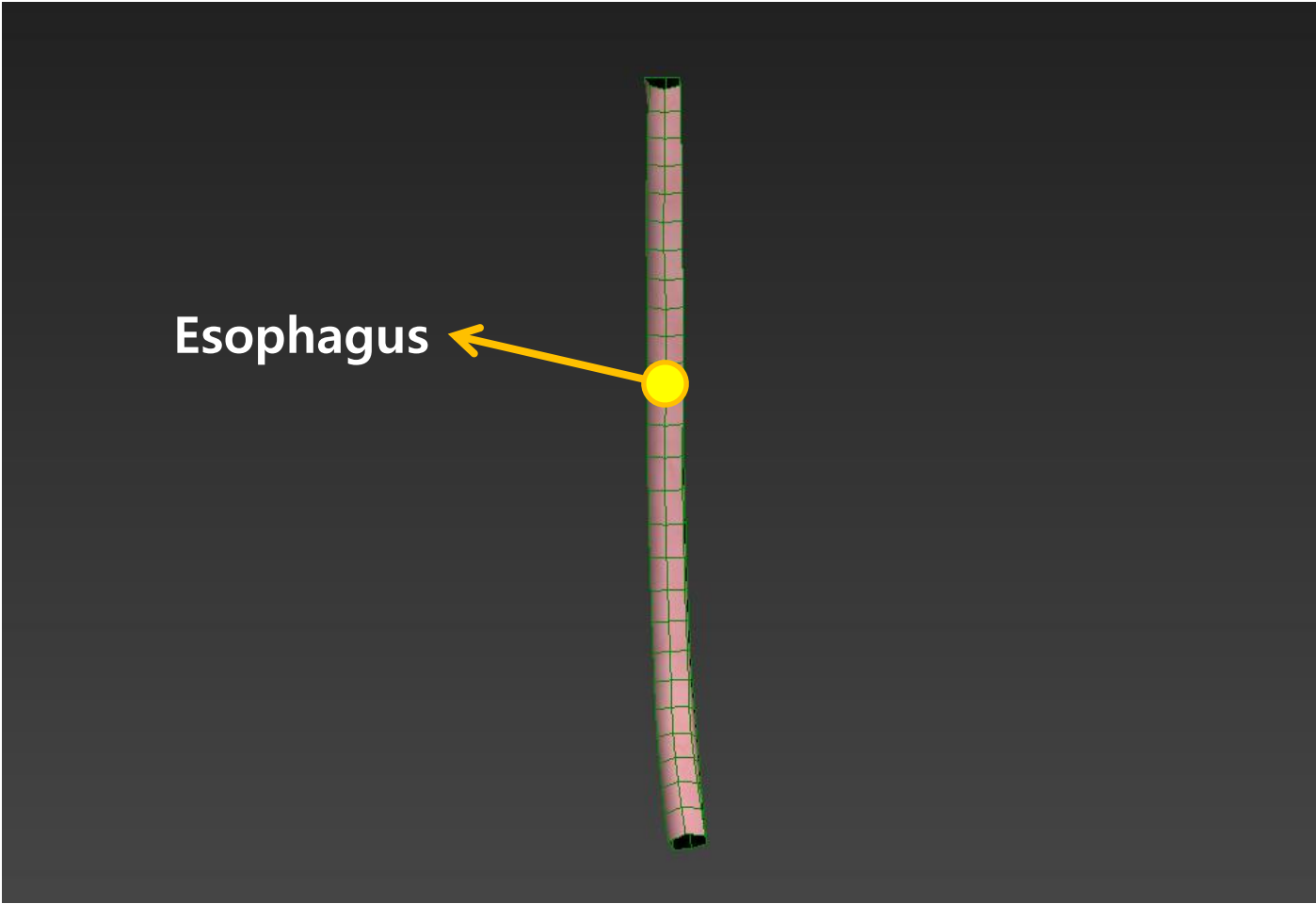
<http://www.wikipedia.com/>



https://www.innerbody.com/image_dige01/dige03-new2.html

Esophagus Modeling

3ds Max Viewport Shot



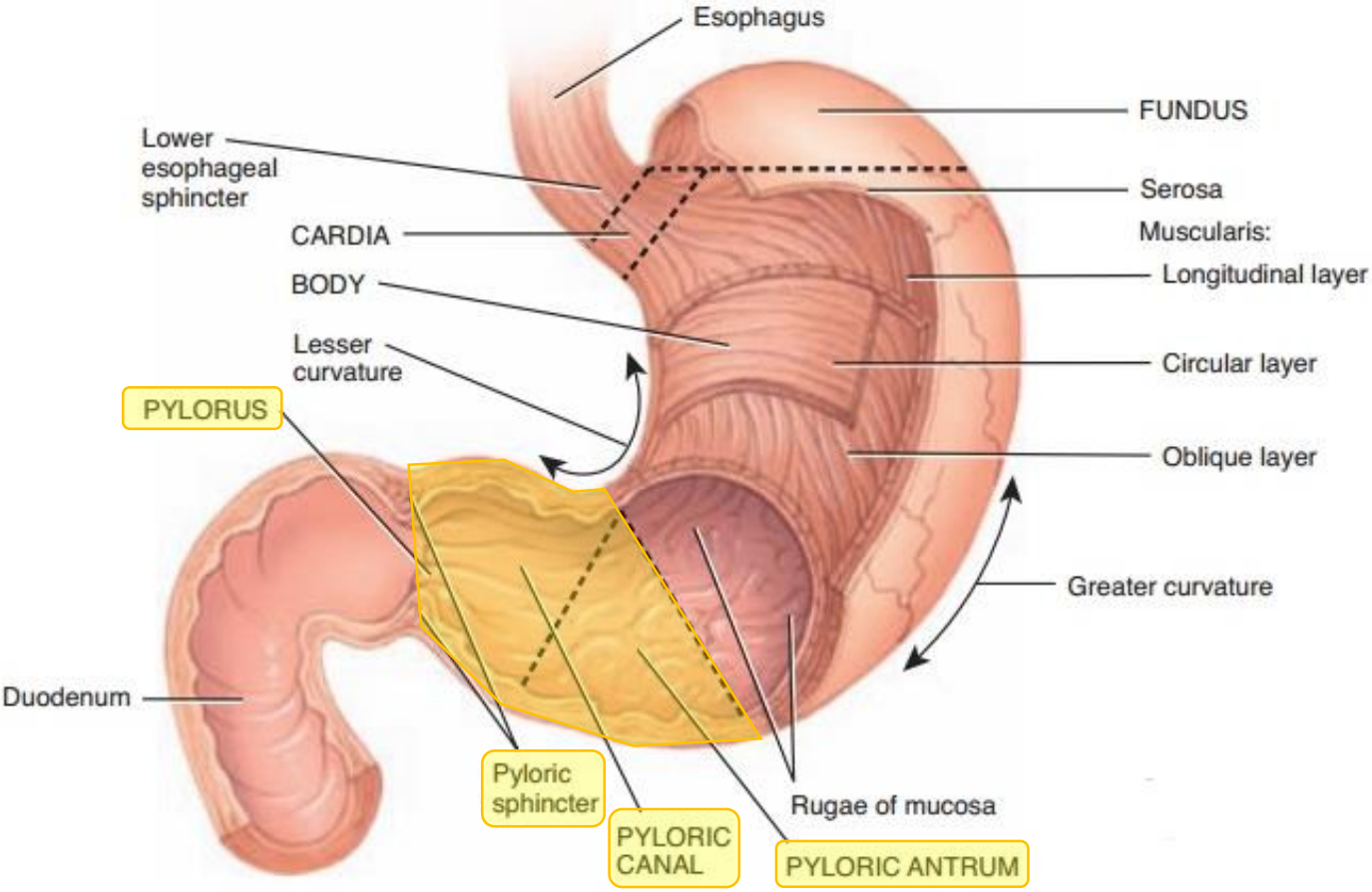
x3d Viewer



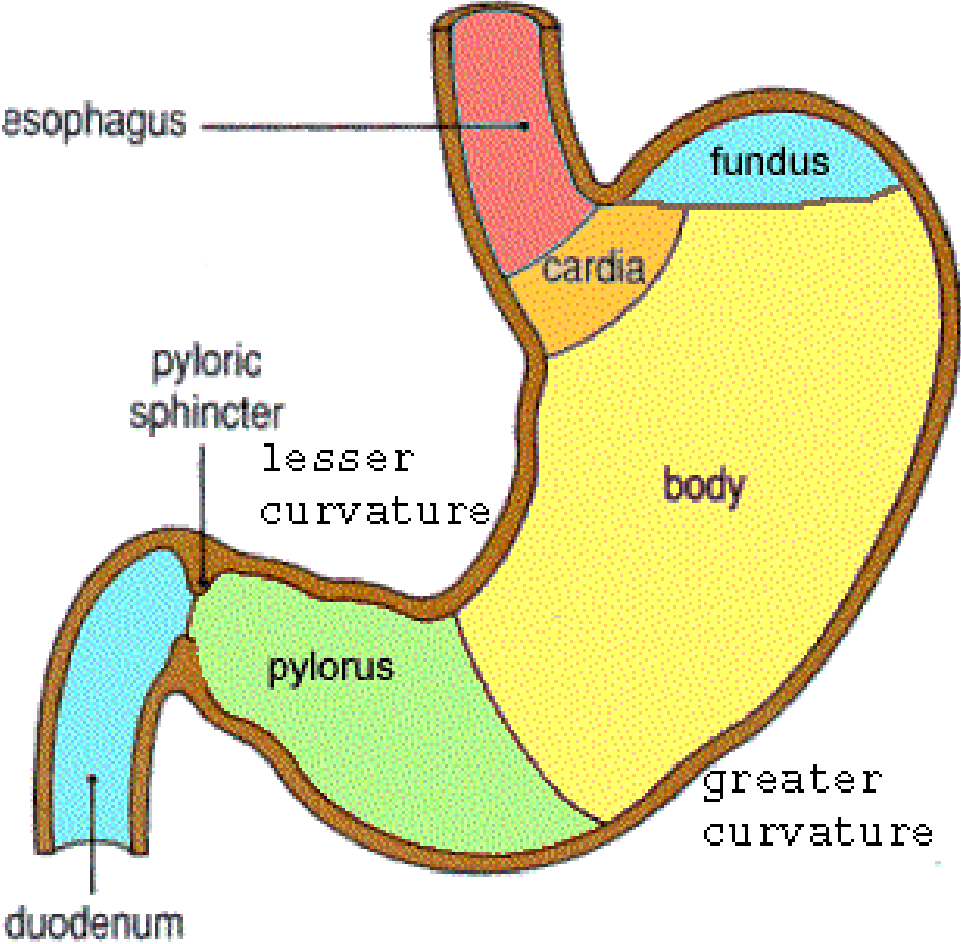
Esophagus X3D Structure

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Digestive System - Stomach



(a) Anterior view of regions of stomach



Digestive System - Stomach

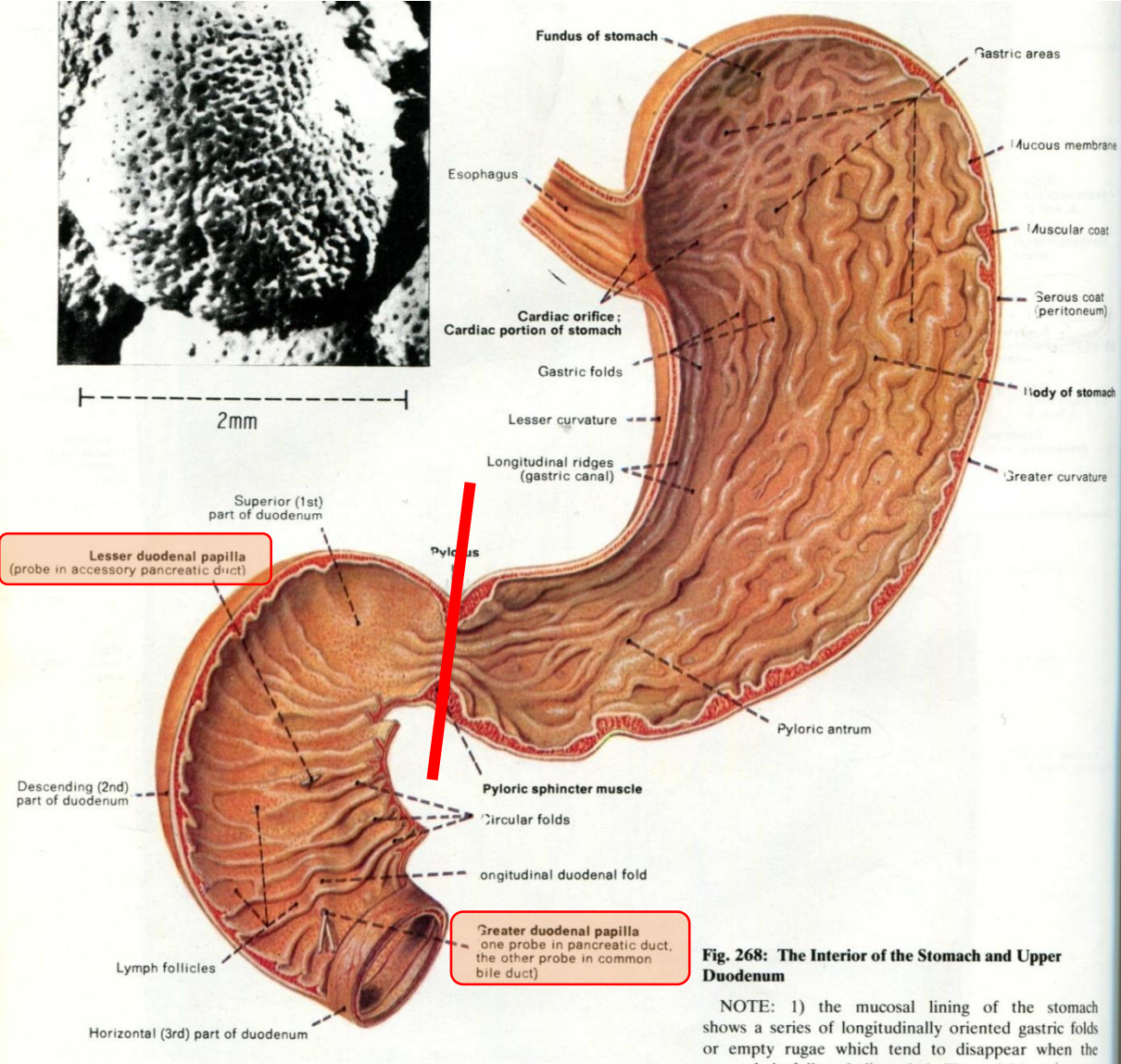
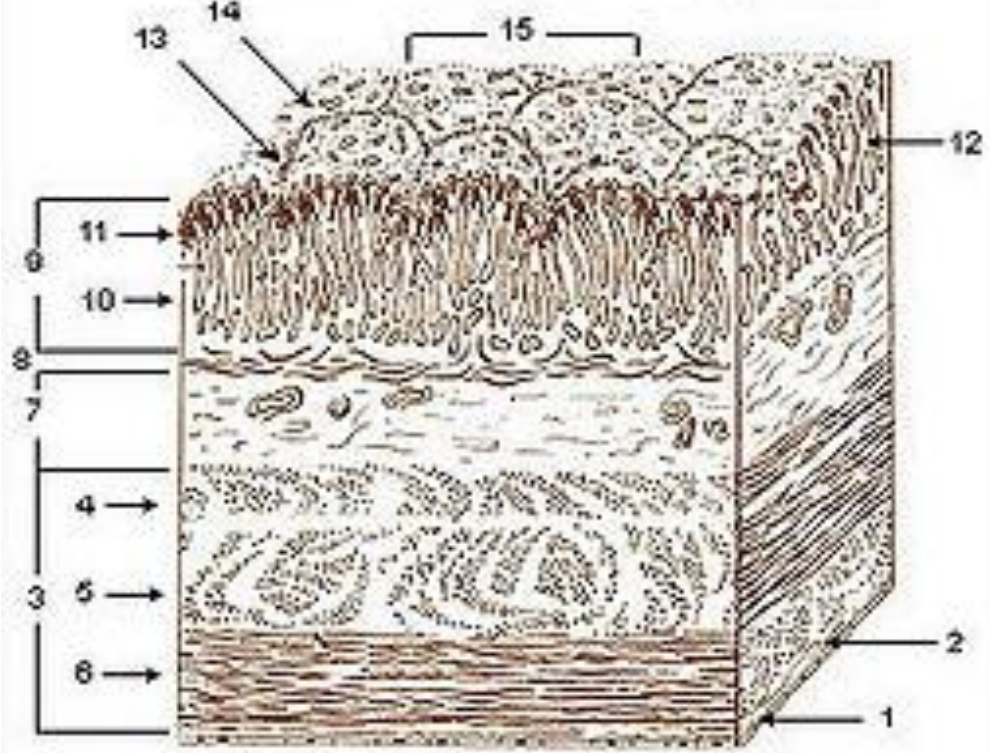


Fig. 268: The Interior of the Stomach and Upper Duodenum

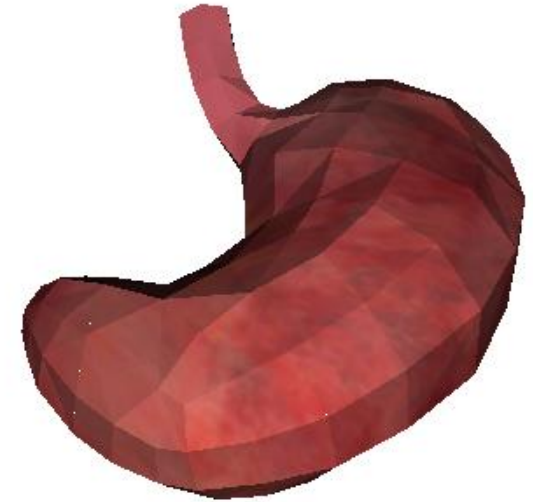
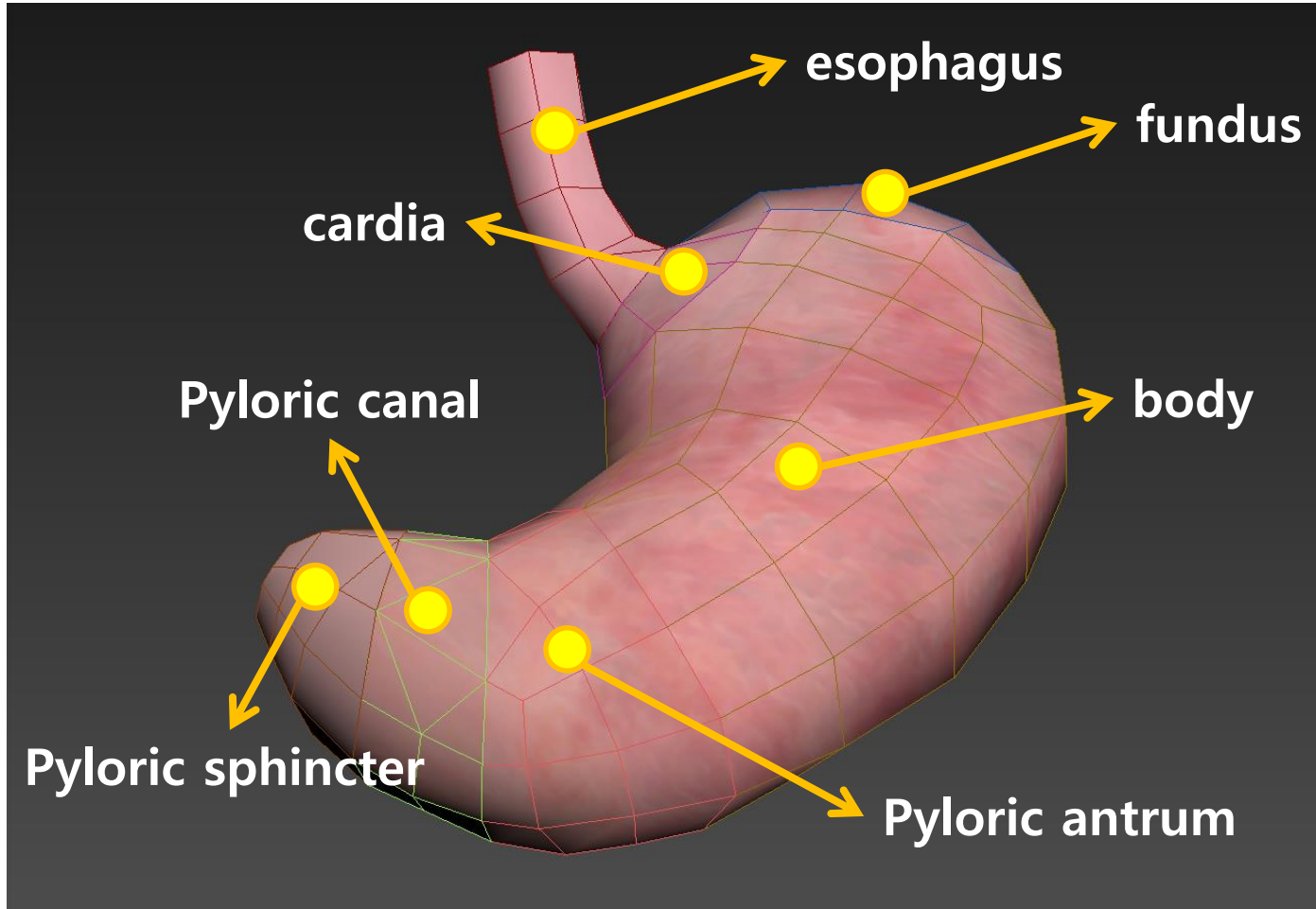
NOTE: 1) the mucosal lining of the stomach shows a series of longitudinally oriented gastric folds or empty rugae which tend to disappear when the



Layers of Stomach Wall:

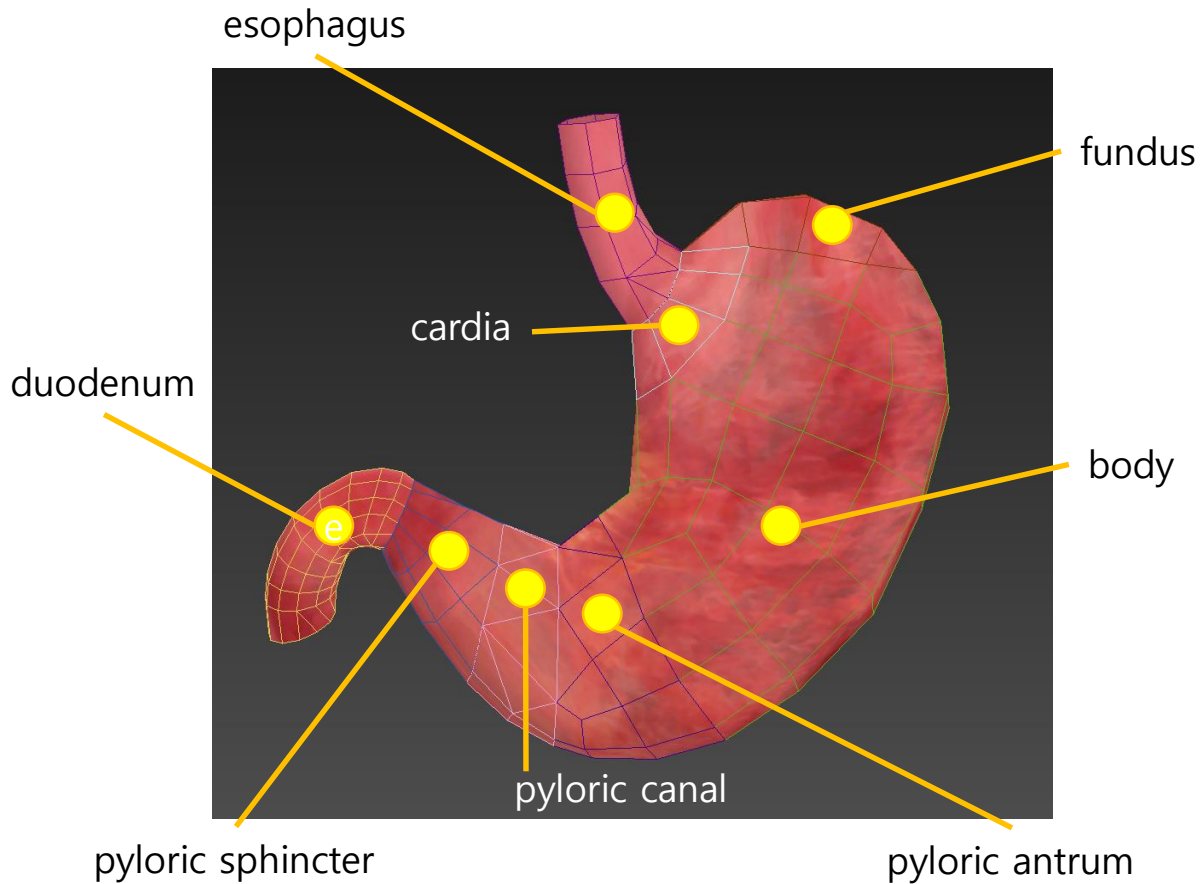
Stomach Modeling

3ds Max Viewport Shot

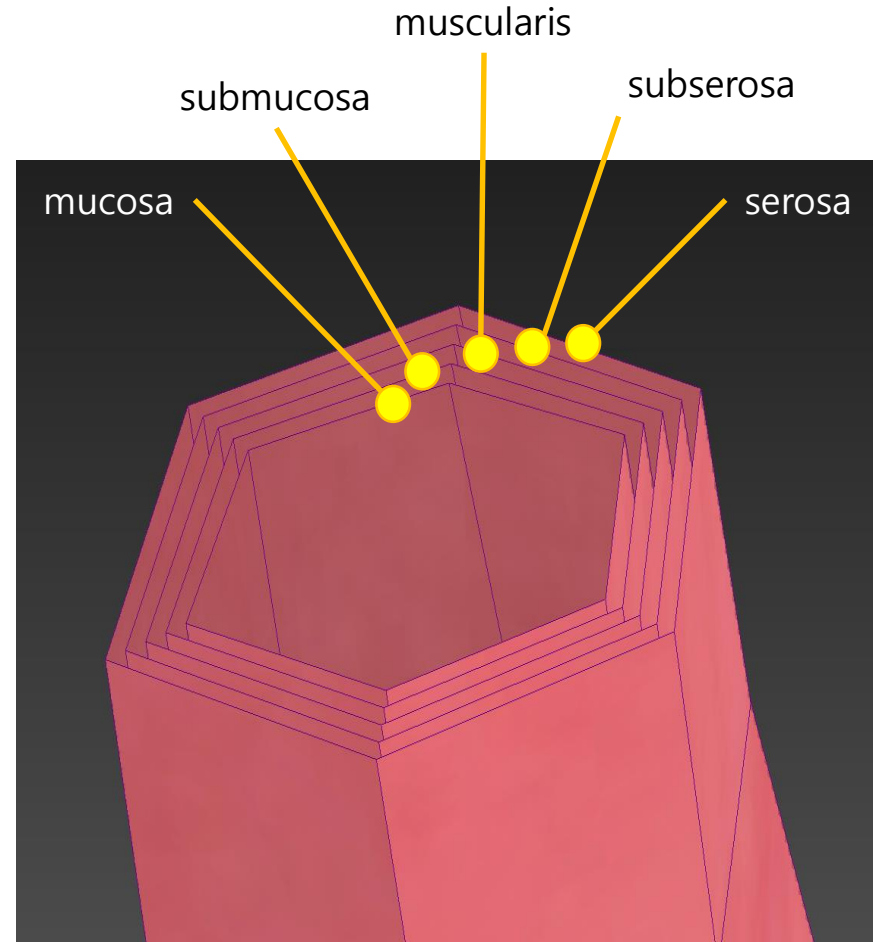


x3d Viewer Image

Stomach Modeling



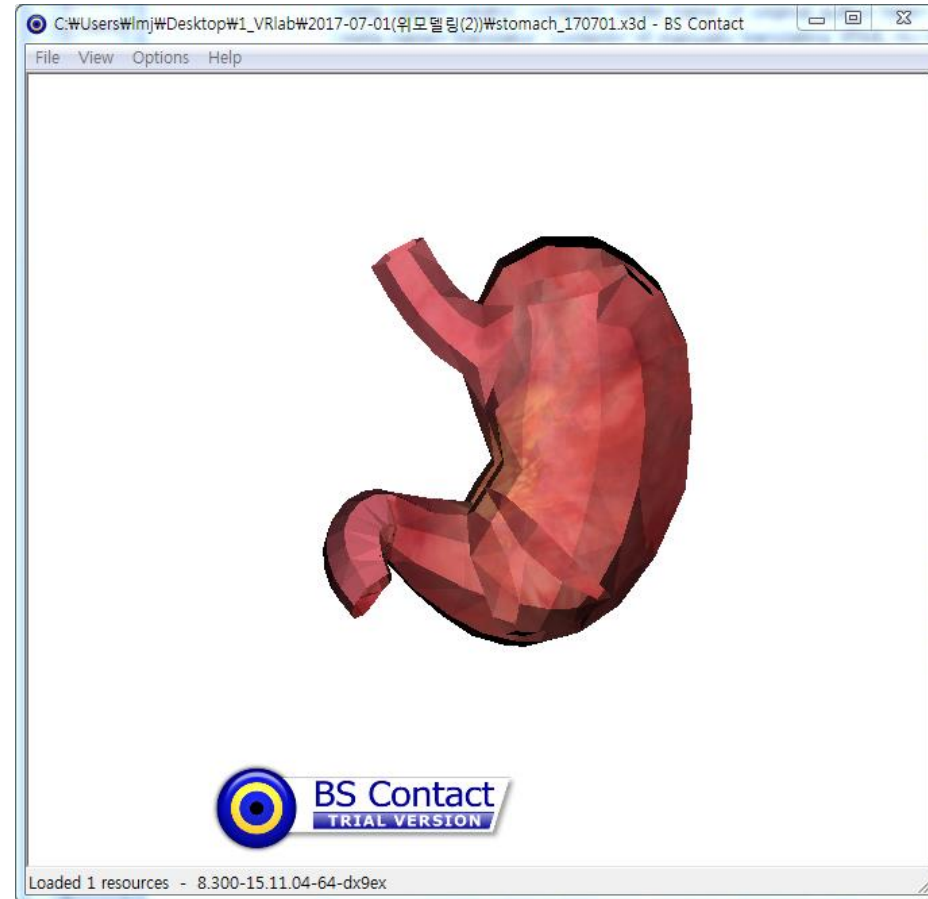
Stomach



Stomach layer

Stomach X3D

Problem in layers
modeling:
Some polygons turned
outside and intermingled



Stomach X3D Structure

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Digestive organs - Duodenum

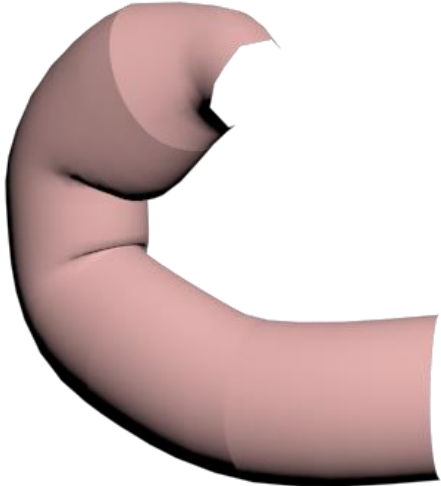
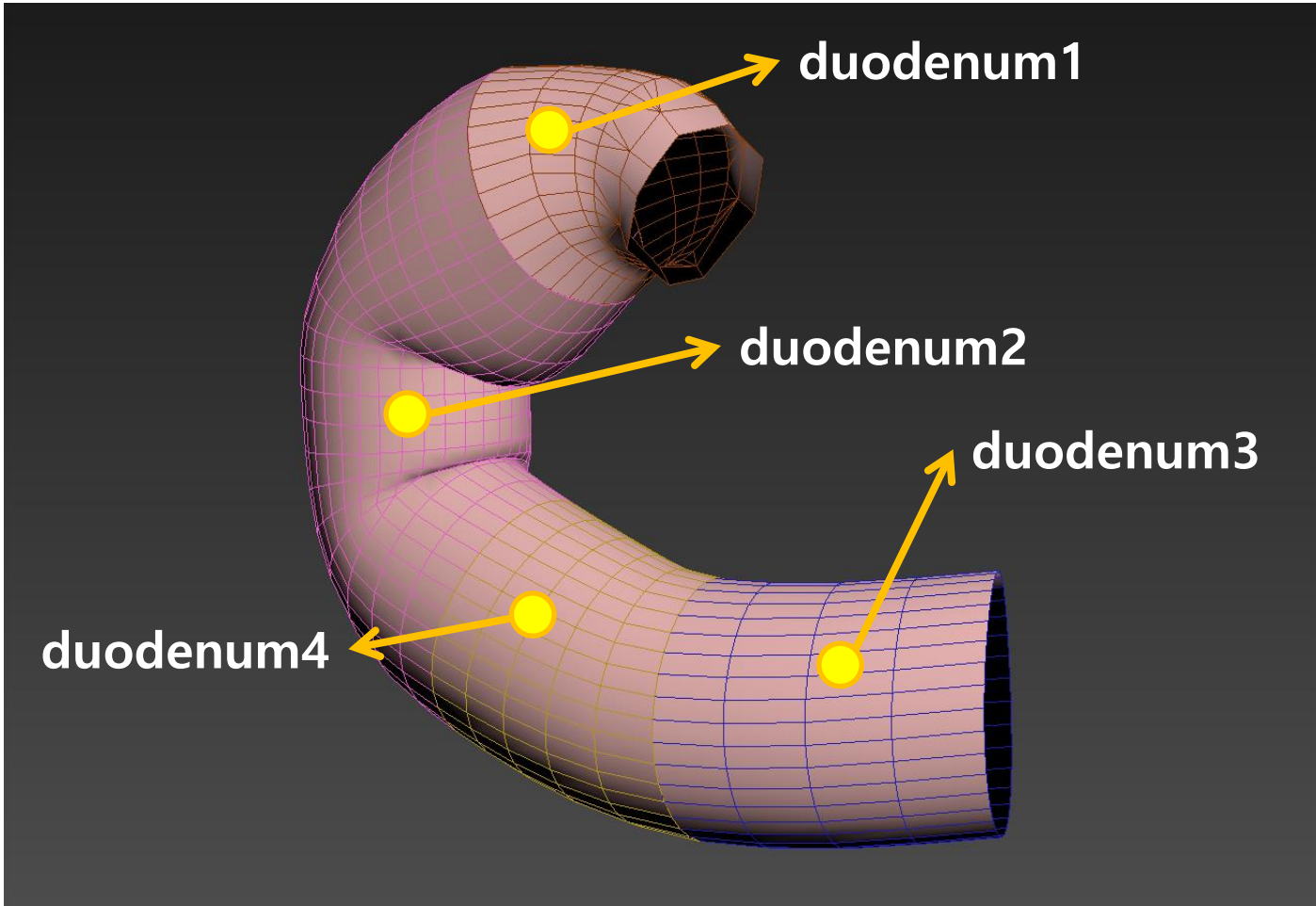
Duodenum - parts

25 cm long & Subdivided into 4 parts

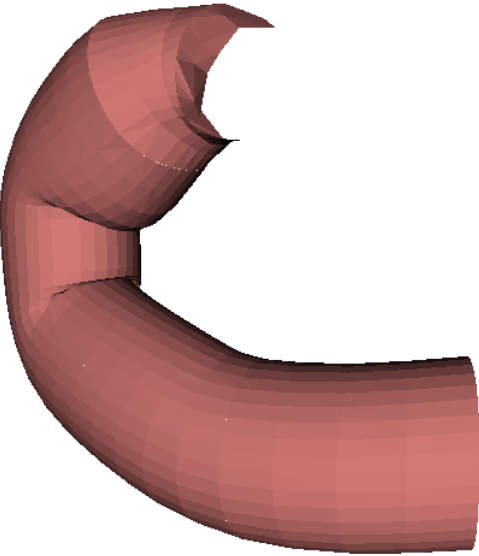
First	/ upper part	– 5 cm
Second	/ vertical part	– 7.5 cm
Third	/ horizontal part	– 10 cm
Fourth	/ ascending part	– 2.5 cm

Duodenum Modeling

3ds Max Viewport Shot



Rendering Image

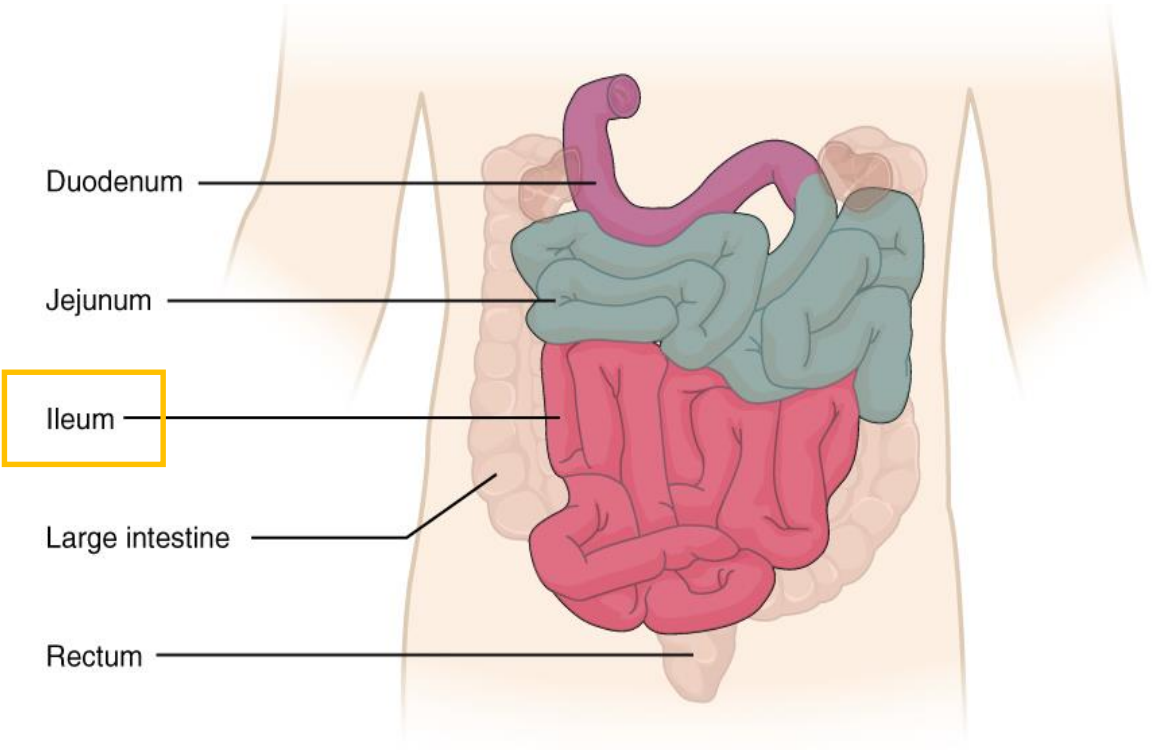
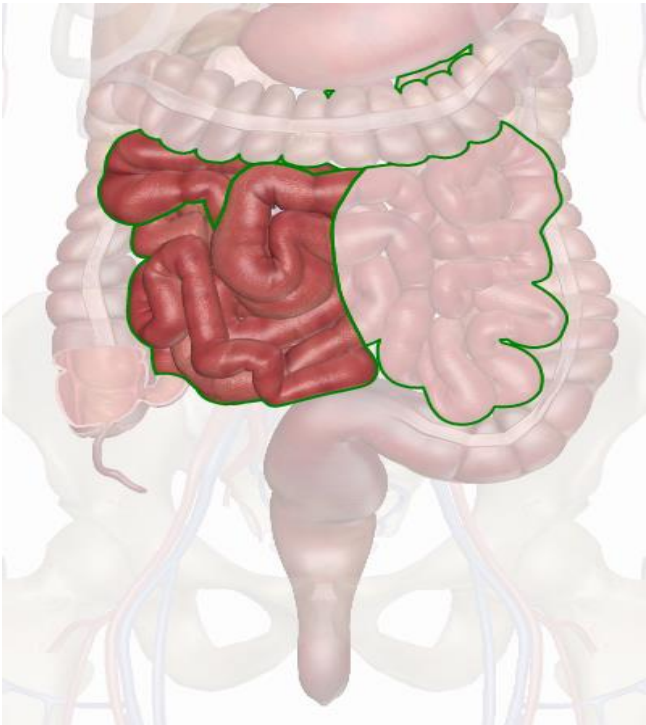


x3d Viewer Image

Duodenum X3D Structure

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  <meta name='generator' content='X3D-Edit, https://savage.nps.edu/X3D-Edit'/>
  <meta name='license' content='.././license.html'/>
</head>
<Scene>
  <Viewpoint position='0 0 200'/>
  <Background groundColor='1 1 1' skyColor='1 1 1'/>
  <Transform DEF="duodenum2" translation="-19.07 11.62 -11.71">
    <Shape >
      <Appearance >
        <Material ambientIntensity="1.0" transparency="0.0" shininess="0.145" diffuseColor="0.588 0.588 0.588" specularColor="0.0 0.0 0.0"/>
        <ImageTexture url="small_intestine.jpg"/>
      </Appearance>
      <IndexedFaceSet DEF="duodenum2-FACES" coordIndex=" 0 1 2 -1 2 3 0 -1 1 4 5 -1 5 2 1 -1 6 7 8 -1 8 9 6 -1 9 8 3 -1 3 2 9 -1 10 9 2 -1 2 5 10 -1 11 6 9 -1 9 10 11 -
        <TextureCoordinate DEF="duodenum2-TEXCOORD" point="0.6468 0.8972, 0.6333 0.9207, 0.6333 0.9207, 0.6468 0.8972, 0.6197 0.9442, 0.6197 0.9442, 0.6333 0.920
        <Coordinate DEF="duodenum2-COORD" point="14.3 -31.27 -11.29, 13.18 -33.76 -11.28, 10.01 -31.05 -14.41, 11.1 -28.57 -14.35, 11.84 -36.06 -10.92, 8.673 -33.34
      </IndexedFaceSet>
    </Shape>
  </Transform>
  <Transform DEF="duodenum4" translation="26.47 -27.09 10.12">
    <Shape >
      <Appearance >
        <Material ambientIntensity="1.0" transparency="0.0" shininess="0.145" diffuseColor="0.588 0.588 0.588" specularColor="0.0 0.0 0.0"/>
        <ImageTexture url="small_intestine.jpg"/>
      </Appearance>
      <IndexedFaceSet DEF="duodenum4-FACES" coordIndex=" 3 4 5 -1 5 6 3 -1 4 3 8 -1 8 7 4 -1 0 4 7 -1 7 2 0 -1 1 5 4 -1 4 0 1 -1 144 145 9 -1 9 10 144 -1 11 9 145 -1
        <TextureCoordinate DEF="duodenum4-TEXCOORD" point="0.6333 0.9207, 0.6197 0.9442, 0.6468 0.8972, 0.6333 0.9207, 0.6333 0.9207, 0.6197 0.9442, 0.6197 0.944
        <Coordinate DEF="duodenum4-COORD" point="22.75 -7.362 -9.094, 22.69 -9.81 -7.661, 22.77 -4.67 -10.13, 5.503 -8.475 -12.15, 13.83 -8.039 -10.2, 13.62 -10.5 -
      </IndexedFaceSet>
    </Shape>
  </Transform>
```

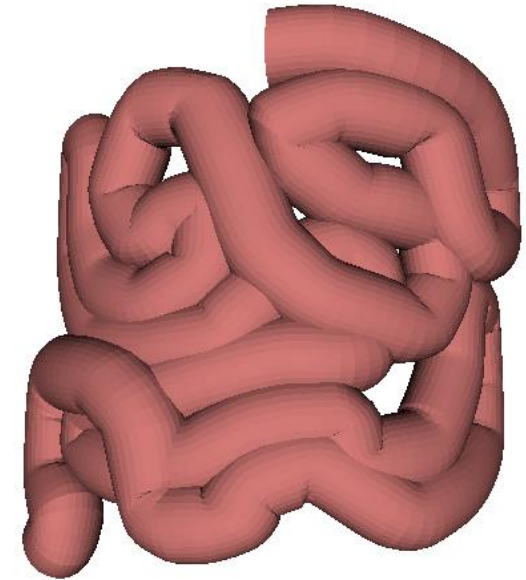
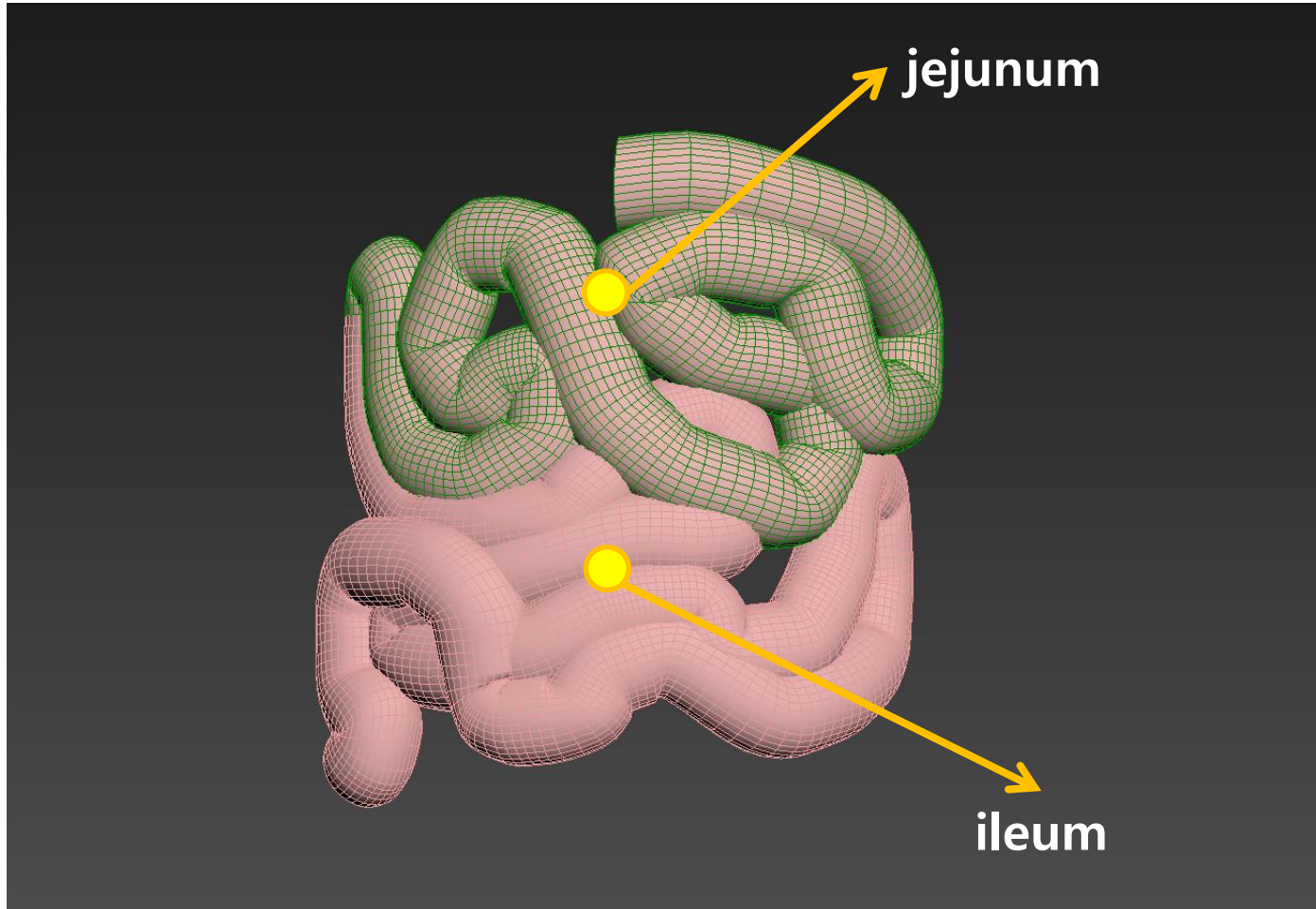
Digestive System – Small Intestine (Ileum)



<http://www.innerbody.com/>

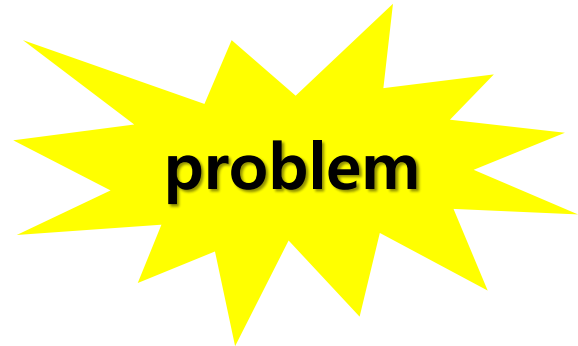
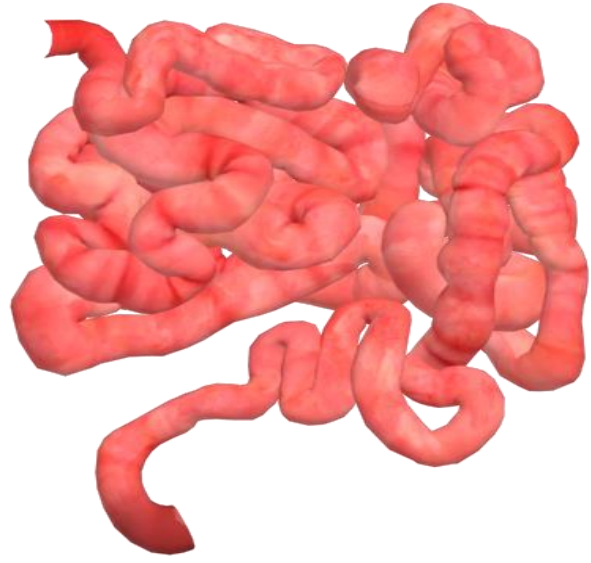
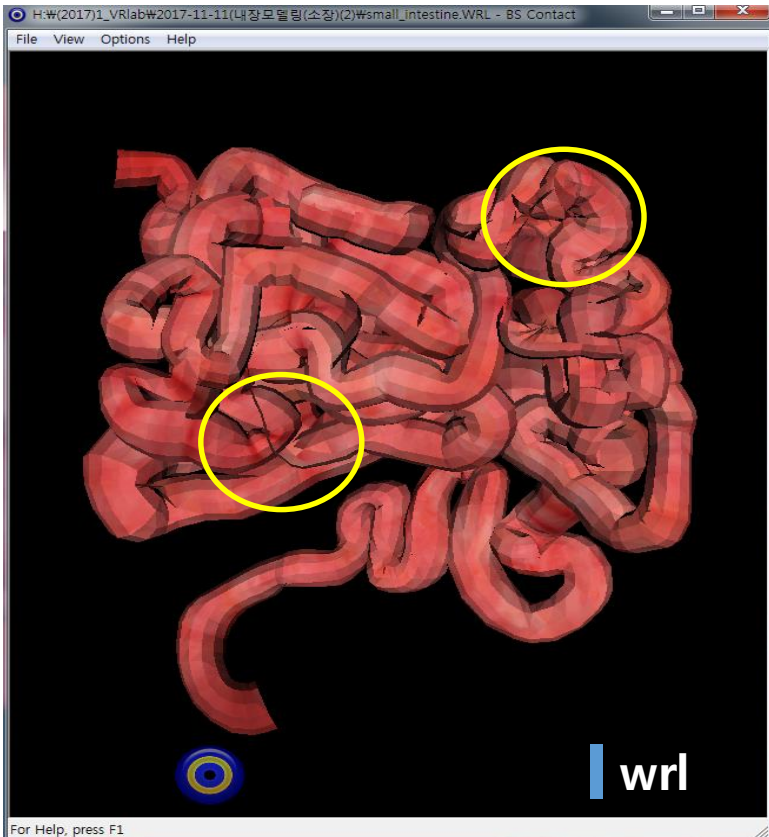
Small Intestine Modeling

3ds Max Viewport Shot

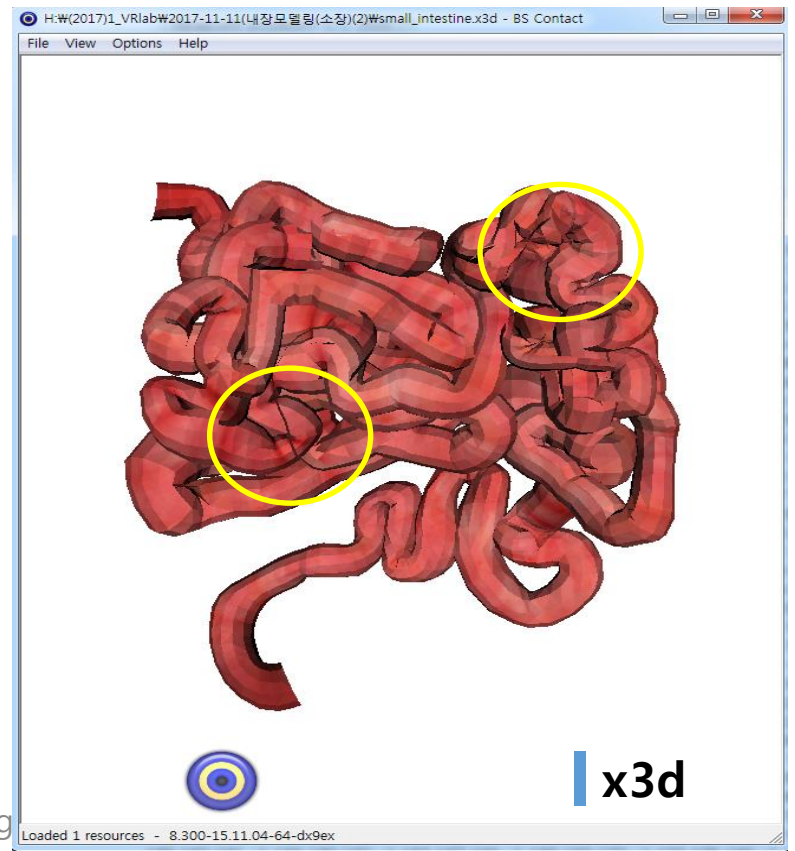


x3d Viewer Image

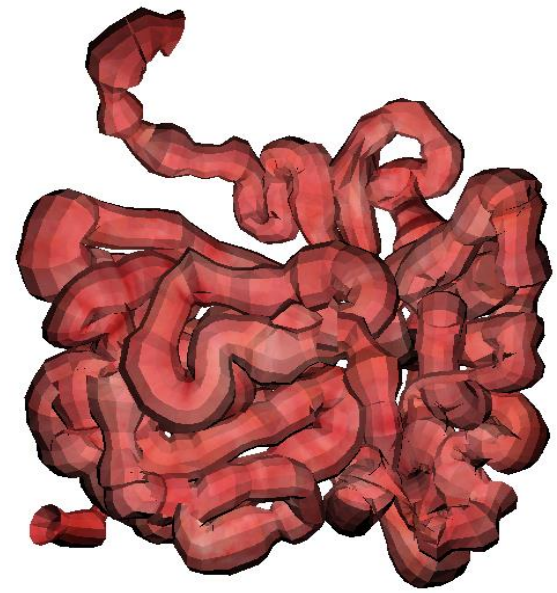
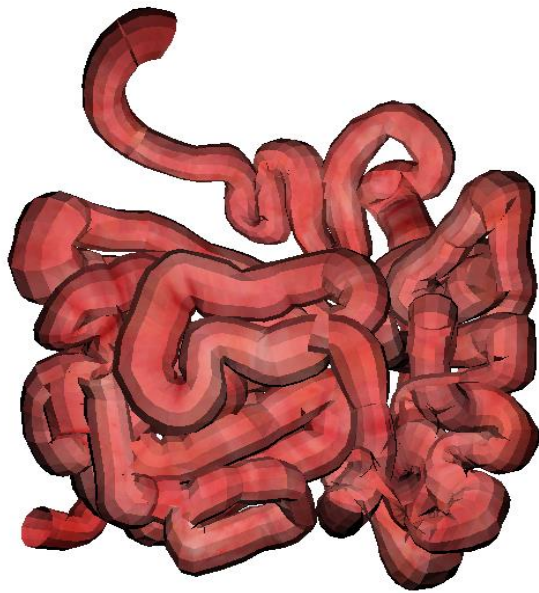
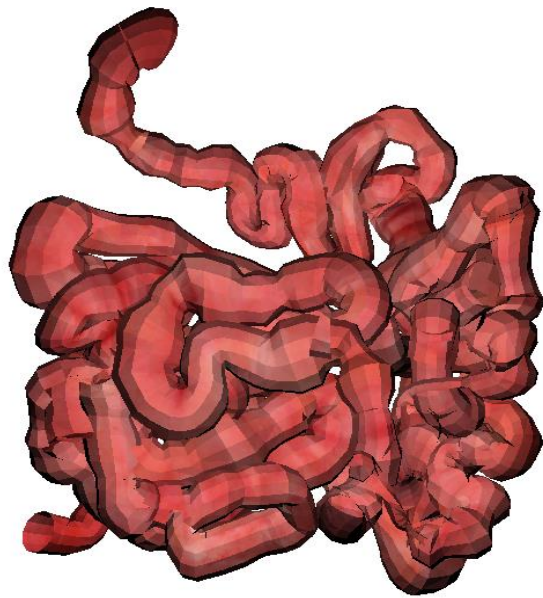
Digestive System – Problem of Small Intestine Modeling



Overlapping polygon



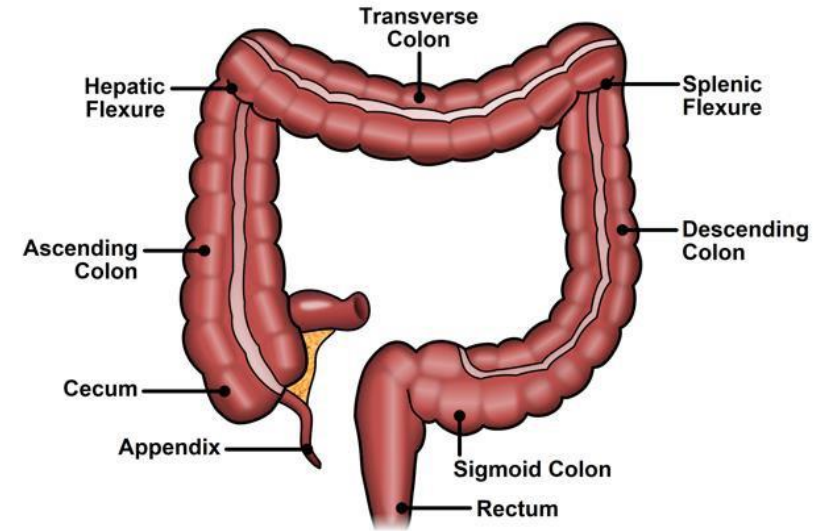
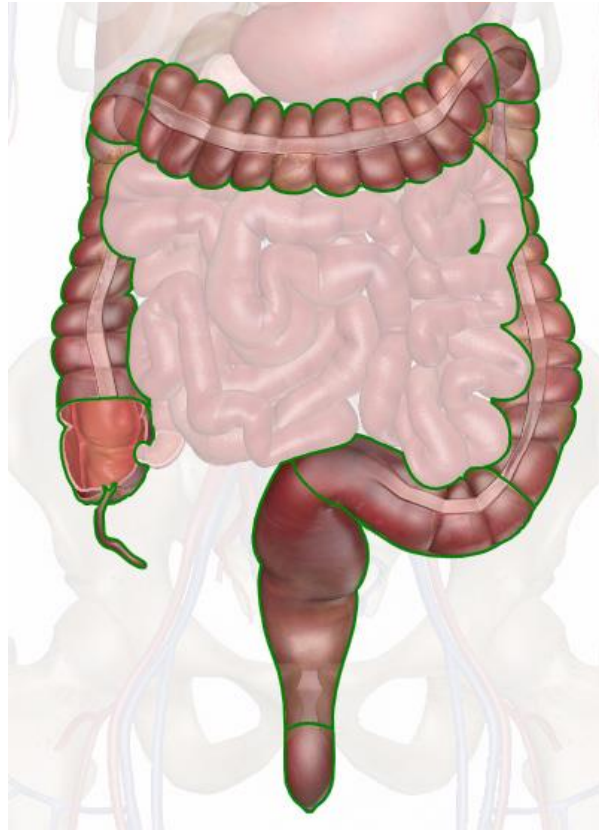
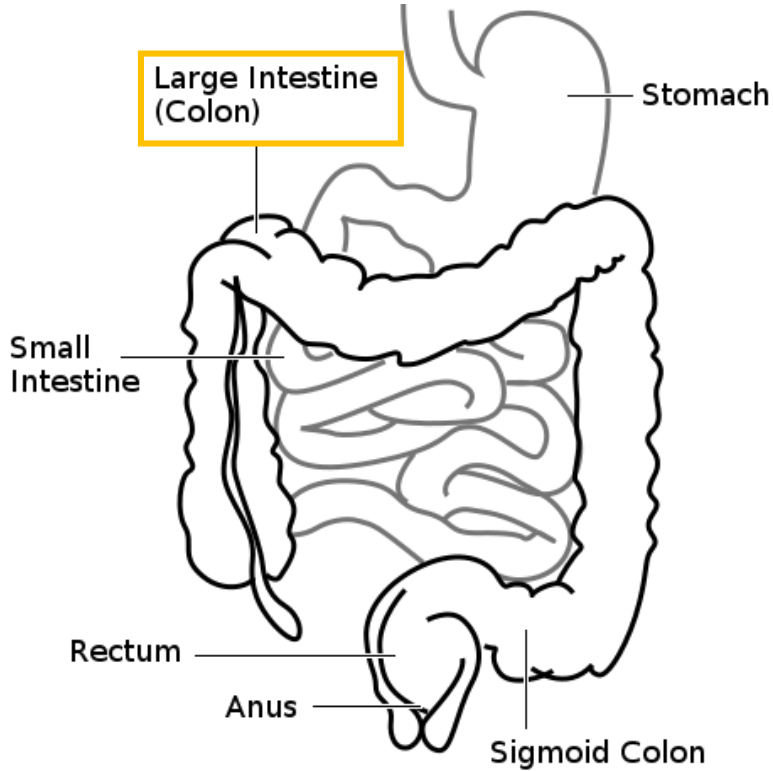
Small Intestine Animation using Interpolators



Small Intestine X3D Structure

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<?xml version='1.0' encoding='UTF-8'?>
<!DOCTYPE X3D PUBLIC "ISO//Web3D//DTD X3D 3.2//EN" "http://www.web3d.org/specifications/x3d-3.2.dtd">
<X3D version='3.2' profile='Immersive' xmlns:xsd='http://www.w3.org/2001/XMLSchema-instance' xsd:noNamespaceSchemaLocation='http://www.web3d.org/specifications/
<head>
  <meta name='title' content='small_intestine.x3d'/>
  <meta name='description' content='*enter description here, short-sentence summaries preferred*/>
  <meta name='creator' content='*enter name of original author here*/>
  <meta name='translator' content='*if manually translating VRML-to-X3D, enter name of person translating here*/>
  <meta name='created' content='*enter date of initial version here*/>
  <meta name='version' content='*enter version here*/>
  <meta name='reference' content='*enter reference citation or relative/online url here*/>
  <meta name='reference' content='*enter additional url/bibliographic reference information here*/>
  <meta name='requires' content='*enter reference resource here if required to support function, delivery, or coherence of content*/>
  <meta name='rights' content='*enter copyright information here* Example: Copyright (c) Web3D Consortium Inc. 2006'/>
  <meta name='drawing' content='*enter drawing filename/url here*/>
  <meta name='image' content='*enter image filename/url here*/>
  <meta name='MovingImage' content='*enter movie filename/url here*/>
  <meta name='photo' content='*enter photo filename/url here*/>
  <meta name='subject' content='*enter subject keywords here*/>
  <meta name='accessRights' content='*enter permission statements or url here*/>
  <meta name='warning' content='*insert any known warnings, bugs or errors here*/>content='Vrml97ToX3dNist, http://ovrt.nist.gov/v2_x3d.html'/>
  <meta name='generator' content='X3D-Edit, https://savage.nps.edu/X3D-Edit'/>
  <meta name='license' content='./../license.html'/>
</head>
<Scene>
  <Viewpoint position='0 0 500'/>
  <Background groundColor='1 1 1' skyColor='1 1 1'/>
  <Transform DEF="small_intestine_ileum" translation="-9.634 -37.75 3.528">
    <Shape >
      <Appearance >
        <Material ambientIntensity="1.0" transparency="0.0" shininess="0.145" diffuseColor="0.588 0.588 0.588" specularColor="0.0 0.0 0.0"/>
        <ImageTexture url="small_intestine.jpg"/>
      </Appearance>
      <IndexedFaceSet DEF="small_intestine_ileum-FACES" coordIndex=" 12267 1 2 -1 2 0 12267 -1 12267 0 4 -1 4 3 12267 -1 5 6 7 -1 7 8 5 -1 6 5 10 -1 10 9 6 -1 0 6 9 -1 9 4 (
        <TextureCoordinate DEF="small_intestine_ileum-TEXCOORD" point="0.6333 0.9207, 0.6333 0.9207, 0.6197 0.9442, 0.6197 0.9442, 0.6468 0.8972, 0.6468 0.8972, 0.6333 0.
        <Coordinate DEF="small_intestine_ileum-COORD" point="-71.96 78.83 -31.29, -73.71 82.8 -29.92, -73.88 79.11 -29.5, -70.19 82.23 -33.8, -70.35 78.54 -33.37, -72.21 72
      </IndexedFaceSet>
    </Shape>
  </Transform>
  <Transform DEF="small_intestine_jejunem" translation="0.9395 40.66 -5.853">
    <Shape >
      <Appearance >
        <Material ambientIntensity="1.0" transparency="0.0" shininess="0.145" diffuseColor="0.588 0.588 0.588" specularColor="0.0 0.0 0.0"/>
        <ImageTexture url="small_intestine.jpg"/>
      </Appearance>
      <IndexedFaceSet DEF="small_intestine_jejunem-FACES" coordIndex=" 7662 7663 1 -1 1 0 7662 -1 2 7662 0 -1 0 3 2 -1 4 5 6 -1 6 7 4 -1 8 6 5 -1 5 9 8 -1 6 8 3 -1 3 0 6 -1
        <TextureCoordinate DEF="small_intestine_jejunem-TEXCOORD" point="0.6333 0.9207, 0.6333 0.9207, 0.6197 0.9442, 0.6197 0.9442, 0.6468 0.8972, 0.6468 0.8972, 0.6197
        <Coordinate DEF="small_intestine_jejunem-COORD" point="52.79 51.84 -8.667, 53.97 54.39 -8.175, 45.22 51.57 -3.997, 51.86 49.11 -8.806, 65.26 48.74 -19.12, 63.89 46.
      </IndexedFaceSet>
    </Shape>
  </Transform>
</Scene>
</X3D>
```


Digestive System – Large Intestine



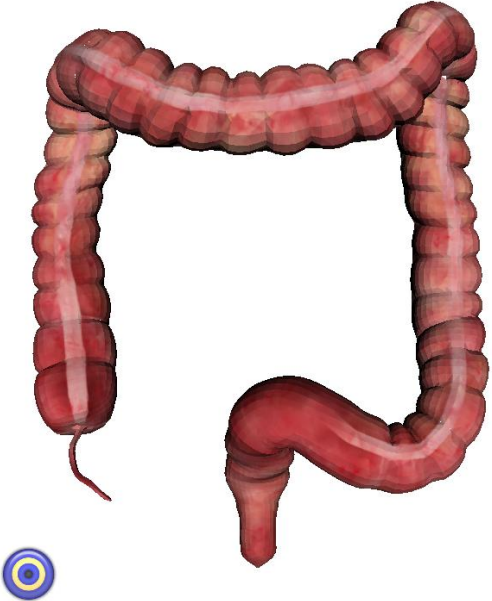
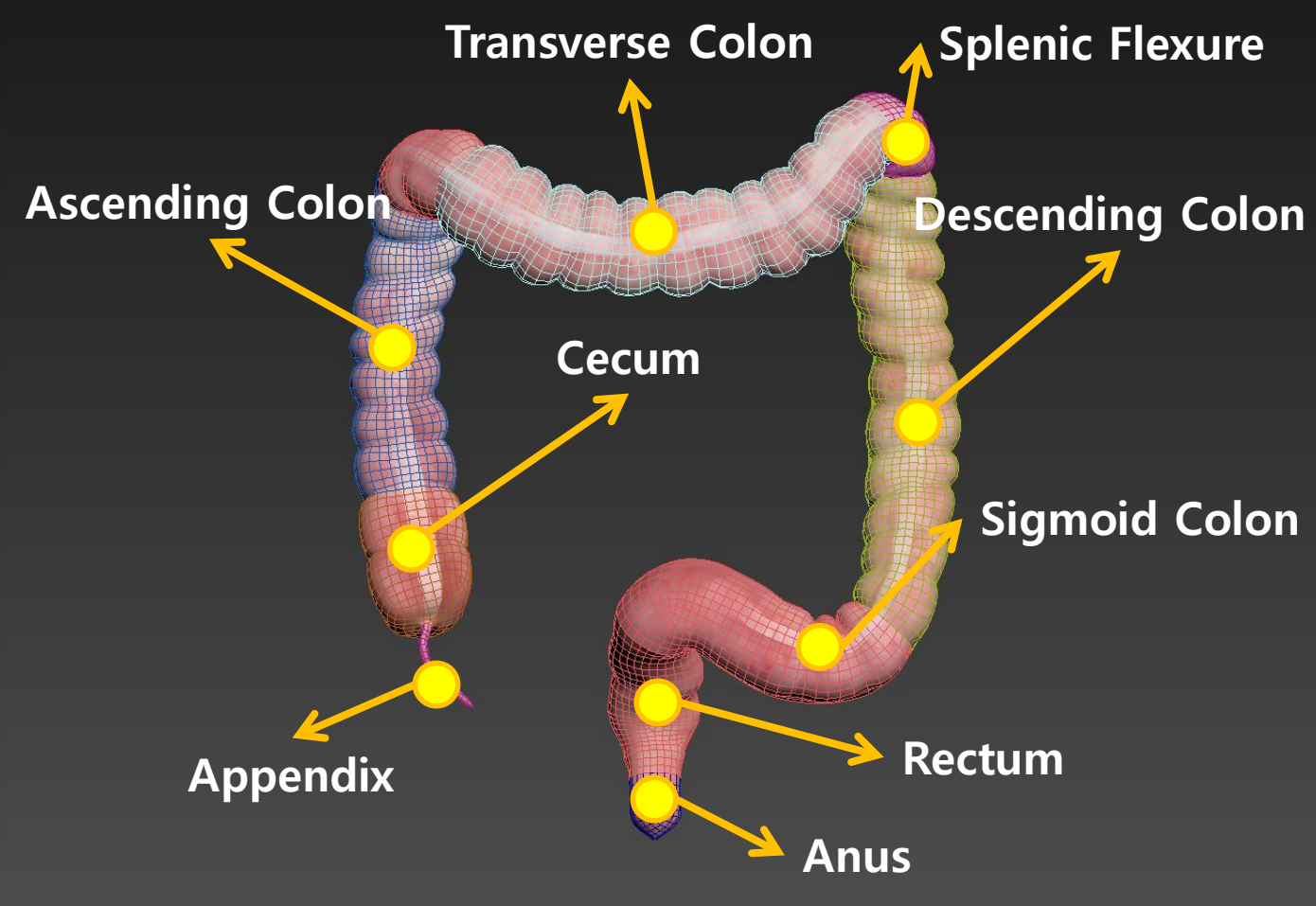
<https://medium.com/@vincentmarger/nutrition-and-digestion-large-intestine-71dab5c05aaf>

http://www.innerbody.com/image_digeov/dige10-new3.html

Front of abdomen, showing the large intestine, with the stomach and small intestine in gray outline
https://en.wikipedia.org/wiki/Large_intestine

Large Intestine Modeling

3ds Max Viewport Shot

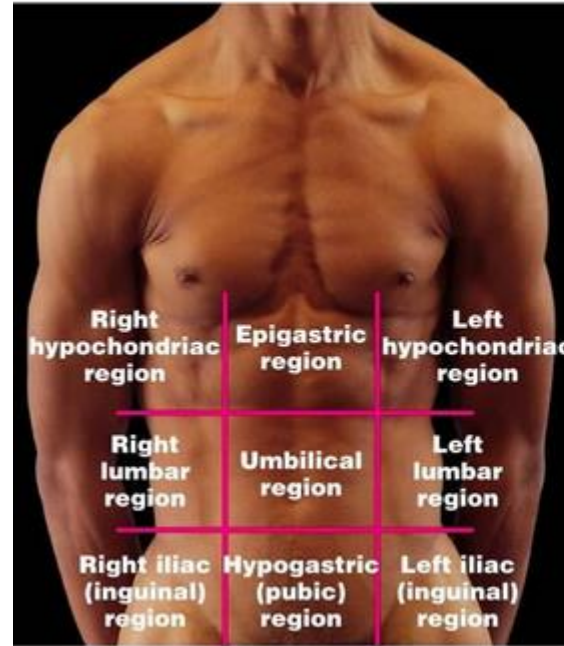
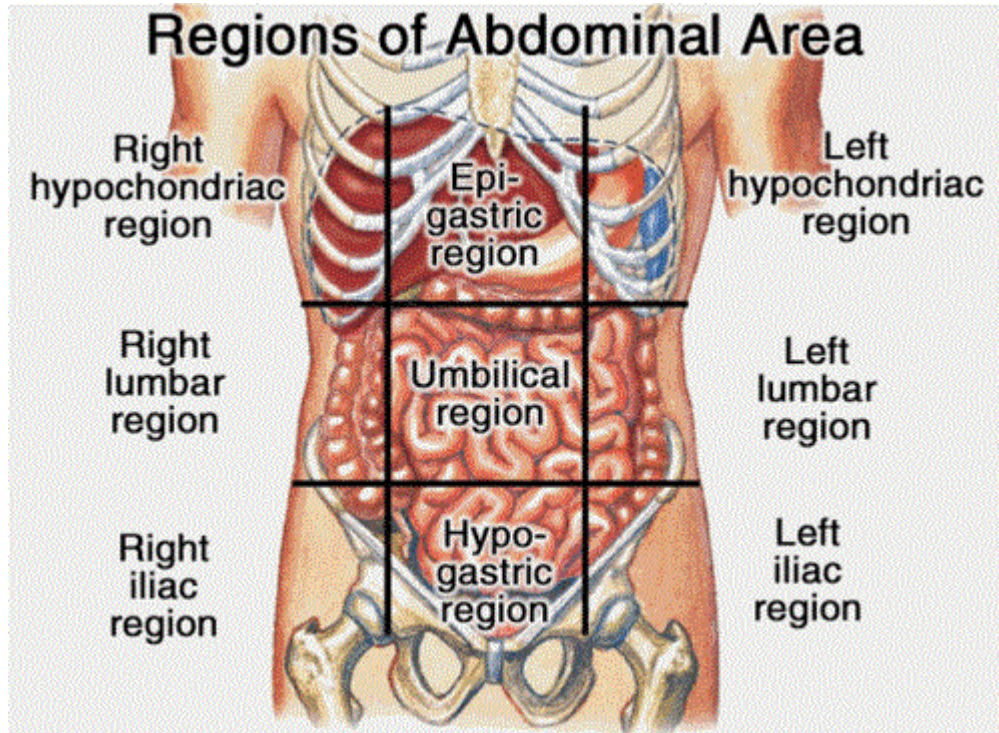


x3d Viewer Image

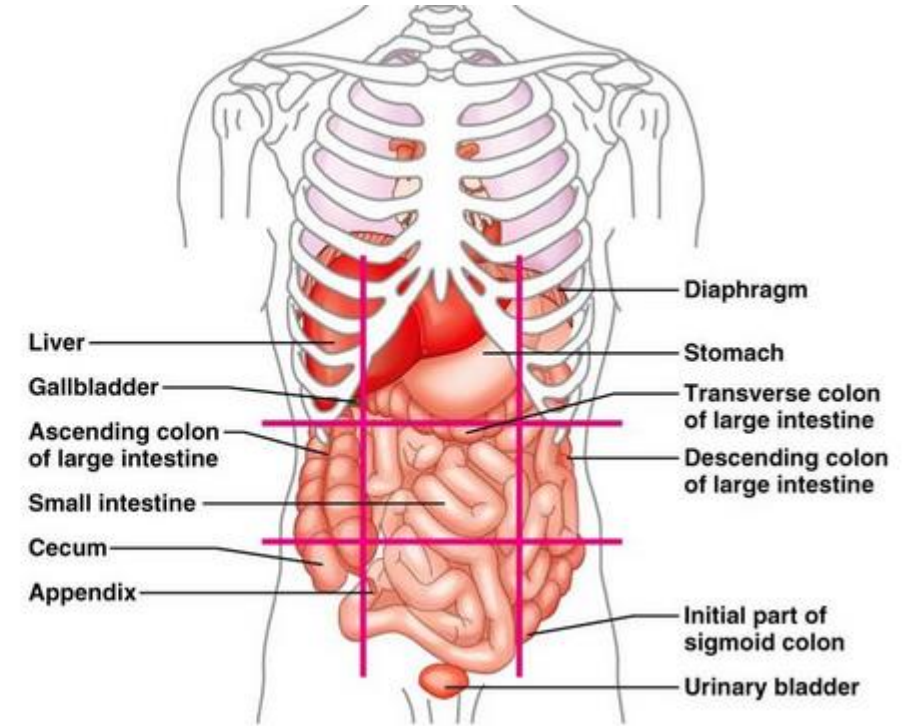
Large Intestine X3D Structure

```
<?xml version='1.0' encoding='UTF-8'?>
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<X3D version='3.2' profile='Immersive' xmlns:xsd='http://www.w3.org/2001/XMLSchema-instance' xsd:noNamespaceSchemaLocation='http://www.web3d.org/specifications
<head>
  <meta name='title' content='large_intestine.x3d'/>
  <meta name='description' content='*enter description here, short-sentence summaries preferred*/>
  <meta name='creator' content='*enter name of original author here*/>
  <meta name='translator' content='*if manually translating VRML-to-X3D, enter name of person translating here*/>
  <meta name='created' content='*enter date of initial version here*/>
  <meta name='version' content='*enter version here*/>
  <meta name='reference' content='*enter reference citation or relative/online url here*/>
  <meta name='reference' content='*enter additional url/bibliographic reference information here*/>
  <meta name='requires' content='*enter reference resource here if required to support function, delivery, or coherence of content*/>
  <meta name='rights' content='*enter copyright information here* Example: Copyright (c) Web3D Consortium Inc. 2006*/>
  <meta name='drawing' content='*enter drawing filename/url here*/>
  <meta name='image' content='*enter image filename/url here*/>
  <meta name='MovingImage' content='*enter movie filename/url here*/>
  <meta name='photo' content='*enter photo filename/url here*/>
  <meta name='subject' content='*enter subject keywords here*/>
  <meta name='accessRights' content='*enter permission statements or url here*/>
  <meta name='warning' content='*insert any known warnings, bugs or errors here*/>
  <meta name='generator' content='Vrml97ToX3dNist, http://ovrt.nist.gov/v2_x3d.html'/>
  <meta name='generator' content='X3D-Edit, https://savage.nps.edu/X3D-Edit'/>
  <meta name='license' content='.././license.html'/>
</head>
<Scene>
  <Viewpoint position='0 0 500'/>
  <Background groundColor='1 1 1' skyColor='1 1 1'/>
  <Transform DEF="large_intestine_splenic_Flexure" translation="132.0 164.3 7.361">
    <Shape >
      <Appearance >
        <Material ambientIntensity="1.0" transparency="0.0" shininess="0.145" diffuseColor="0.588 0.588 0.588" specularColor="0.0 0.0 0.0"/>
        <ImageTexture url="colon.jpg"/>
      </Appearance>
      <IndexedFaceSet DEF="large_intestine_splenic_Flexure-FACES" coordIndex=" 3 0 1 -1 1 2 3 -1 2 4 5 -1 5 3 2 -1 8 9 6 -1 6 7 8 -1 10 11 5 -1 5 12 10 -1 13 217 14 -1 16 17
        <TextureCoordinate DEF="large_intestine_splenic_Flexure-TEXCOORD" point="0.2804 0.448, 0.2793 0.4532, 0.2674 0.4515, 0.274 0.448, 0.2624 0.445, 0.2715 0.4437, 0.2
        <Coordinate DEF="large_intestine_splenic_Flexure-COORD" point="21.0 -3.69 -24.81, 19.28 -0.8395 -26.07, 19.77 3.174 -19.44, 21.16 -1.043 -21.55, 21.74 1.657 -14.56,
      </IndexedFaceSet>
    </Shape>
  </Transform>
  <Transform DEF="large_intestine_anus" translation="15.34 -176.2 -43.93">
    <Shape >
      <Appearance >
        <Material ambientIntensity="1.0" transparency="0.0" shininess="0.145" diffuseColor="0.588 0.588 0.588" specularColor="0.0 0.0 0.0"/>
        <ImageTexture url="colon.jpg"/>
      </Appearance>
      <IndexedFaceSet DEF="large_intestine_anus-FACES" coordIndex=" 0 1 2 -1 2 3 0 -1 4 5 2 -1 2 1 4 -1 7 8 9 -1 9 6 7 -1 6 12 10 -1 10 11 6 -1 14 15 1 -1 1 13 14 -1 231 40 4
        <TextureCoordinate DEF="large_intestine_anus-TEXCOORD" point="0.285 0.8862, 0.2816 0.8931, 0.2793 0.8873, 0.2806 0.8831, 0.2751 0.8925, 0.2755 0.8862, 0.258 0.91E
        <Coordinate DEF="large_intestine_anus-COORD" point="-12.89 0.1512 1.821, -12.75 -3.438 3.537, -12.23 -1.181 5.531, -12.53 0.9597 4.8, -11.19 -4.357 7.79, -11.03 -1.
      </IndexedFaceSet>
    </Shape>
  </Transform>
```

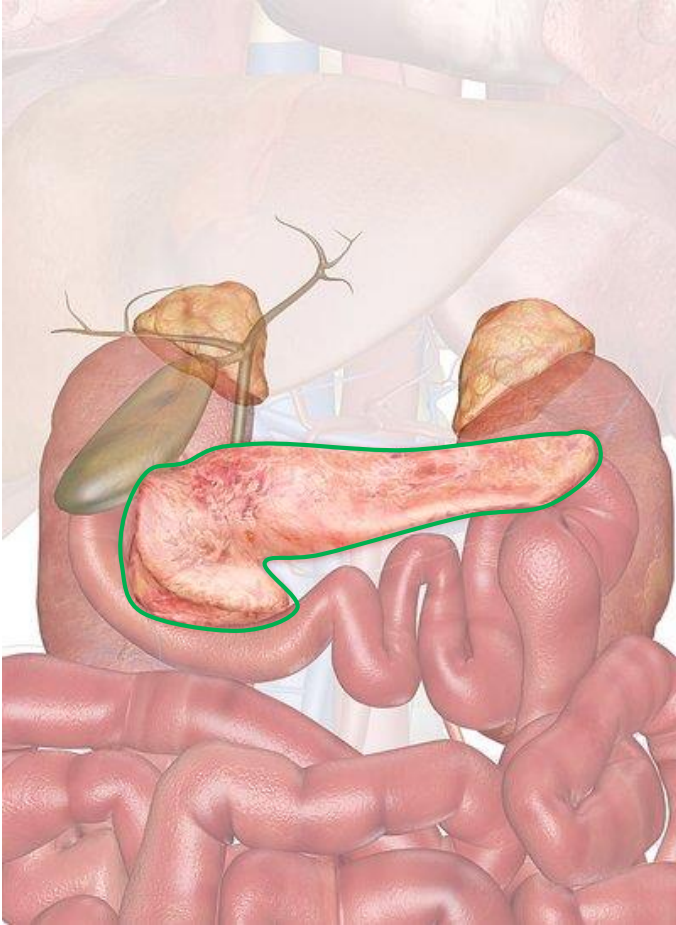
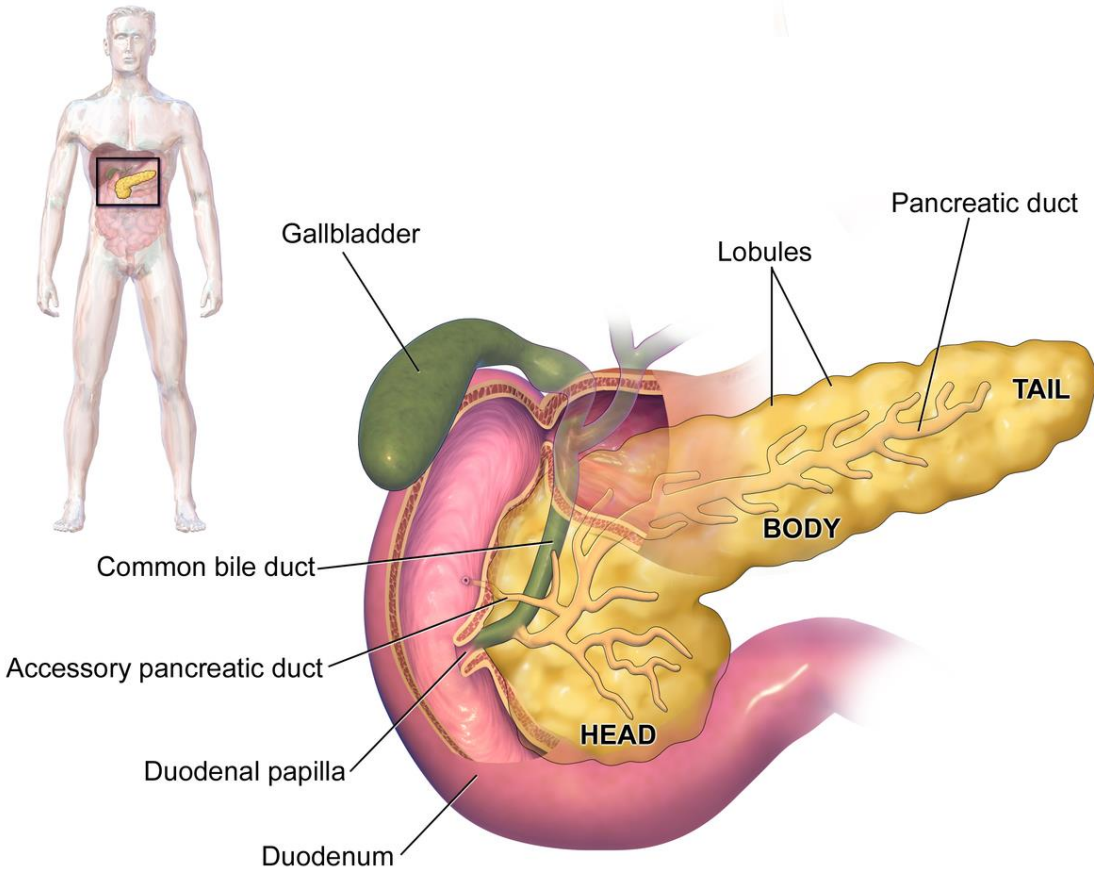
Abdominal Regions



(a)



Digestive System - Pancreas

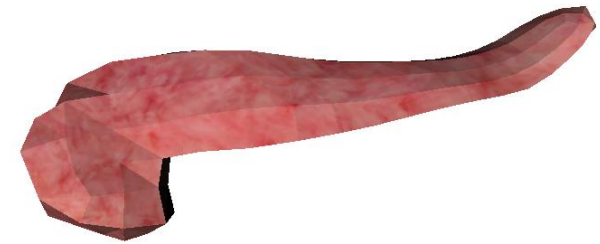
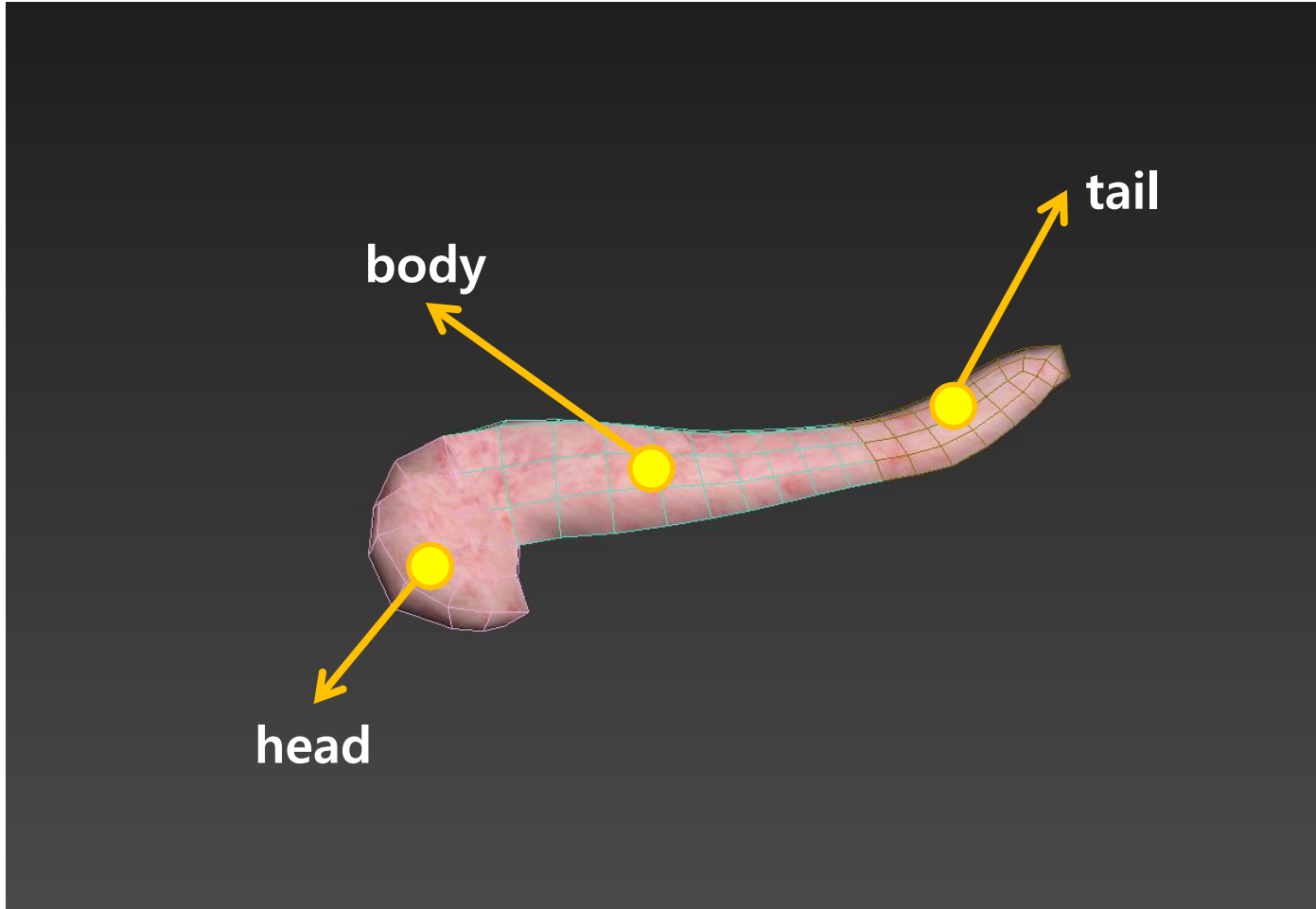


Anatomy of the pancreas
<https://en.wikipedia.org/wiki/Pancreas>

<https://www.innerbody.com/image/endo03.html>

Pancreas Modeling

3ds Max Viewport Shot

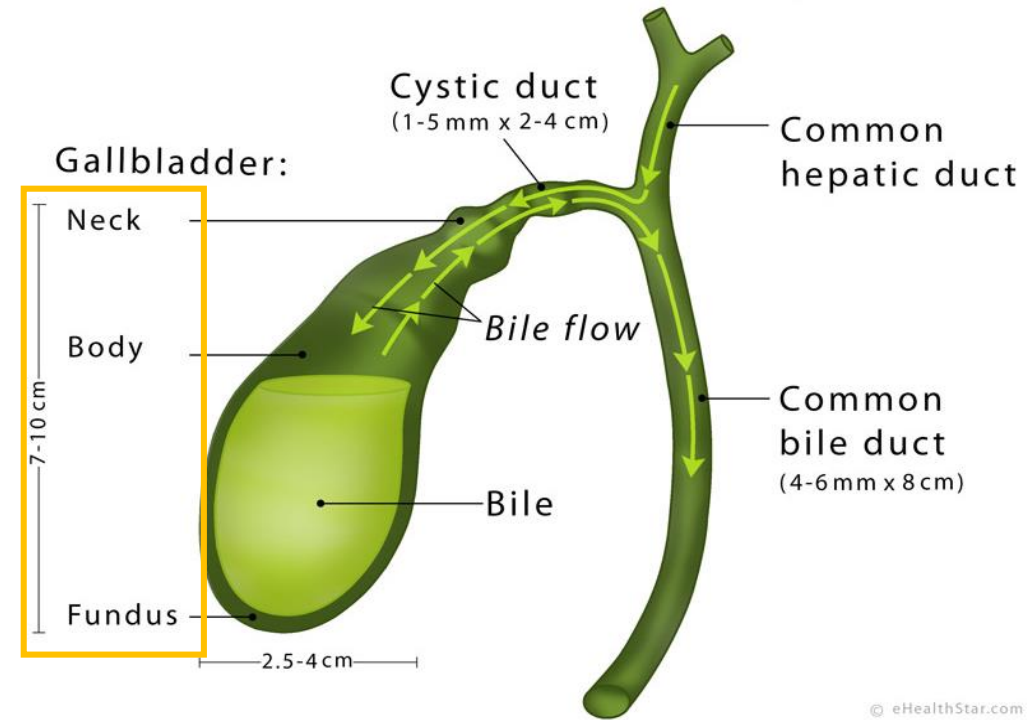
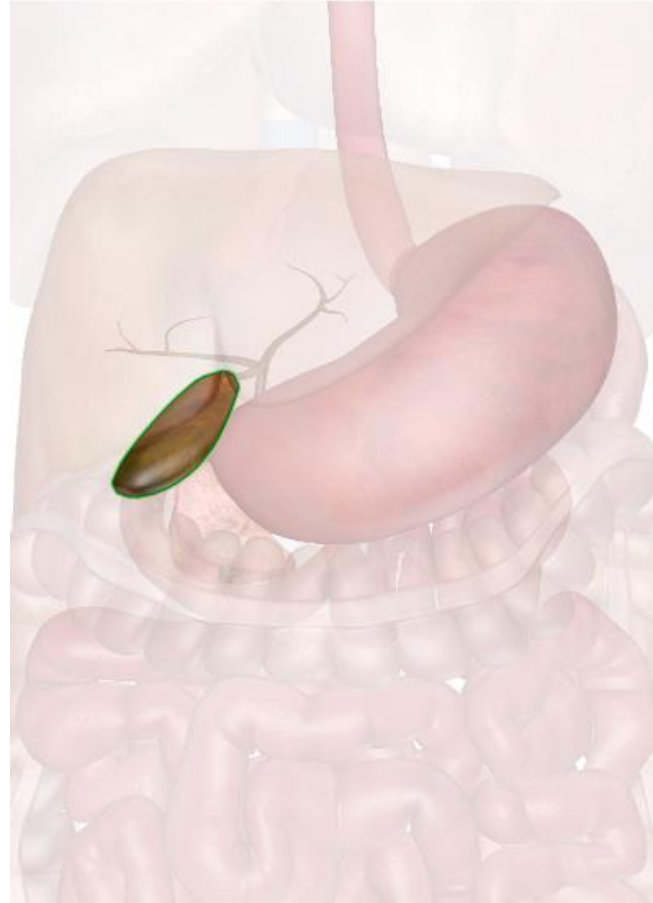
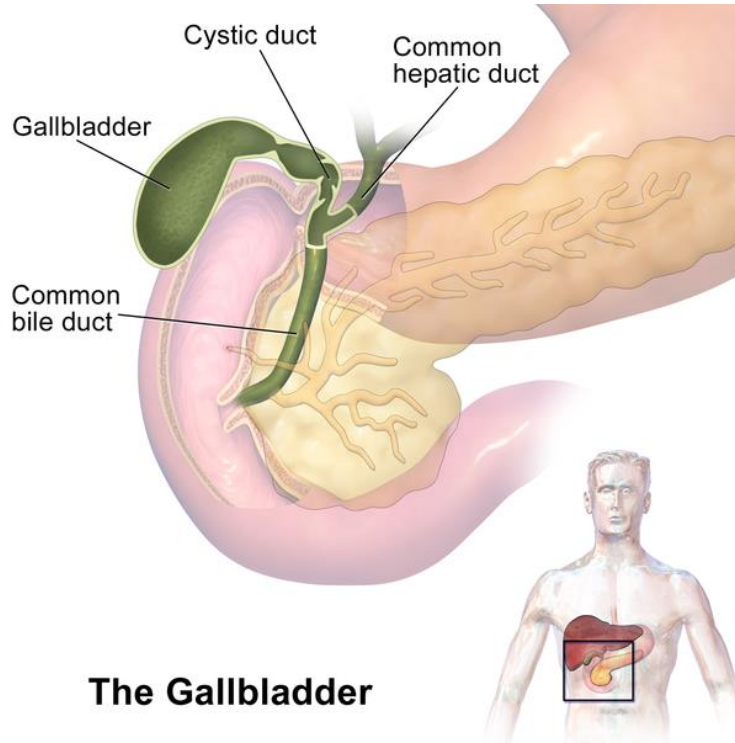


x3d Viewer Image

Pancreas X3D Structure

```
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<X3D version='3.2' profile='Immersive' xmlns:xsd='http://www.w3.org/2001/XMLSchema-instance' xsd:noNamespaceSchemaLocation='http://www.web3d.org/specifi
<head>
  <meta name='title' content='Pancreas.x3d' />
  <meta name='description' content='*enter description here, short-sentence summaries preferred*/>
  <meta name='creator' content='*enter name of original author here*/>
  <meta name='translator' content='*if manually translating VRML-to-X3D, enter name of person translating here*/>
  <meta name='created' content='*enter date of initial version here*/>
  <meta name='version' content='*enter version here*/>
  <meta name='reference' content='*enter reference citation or relative/online url here*/>
  <meta name='reference' content='*enter additional url/bibliographic reference information here*/>
  <meta name='requires' content='*enter reference resource here if required to support function, delivery, or coherence of content*/>
  <meta name='rights' content='*enter copyright information here* Example: Copyright (c) Web3D Consortium Inc. 2006*/>
  <meta name='drawing' content='*enter drawing filename/url here*/>
  <meta name='image' content='*enter image filename/url here*/>
  <meta name='MovingImage' content='*enter movie filename/url here*/>
  <meta name='photo' content='*enter photo filename/url here*/>
  <meta name='subject' content='*enter subject keywords here*/>
  <meta name='accessRights' content='*enter permission statements or url here*/>
  <meta name='warning' content='*insert any known warnings, bugs or errors here*/>
  <meta name='generator' content='Vrml97ToX3dNist, http://ovrt.nist.gov/v2_x3d.html' />
  <meta name='generator' content='X3D-Edit, https://savage.nps.edu/X3D-Edit' />
  <meta name='license' content='.././license.html' />
</head>
<Scene>
  <Viewpoint position='0 0 500' />
  <Background groundColor='1 1 1' skyColor='1 1 1' />
  <Transform DEF="pancreas_body" translation="4.627 -2.169 -4.993">
    <Shape >
      <Appearance >
        <Material ambientIntensity="1.0" transparency="0.0" shininess="0.145" diffuseColor="0.588 0.588 0.588" specularColor="0.0 0.0 0.0"/>
        <ImageTexture url="pancreas.jpg"/>
      </Appearance>
      <IndexedFaceSet DEF="pancreas_body-FACES" coordIndex=" 3 0 1 -1 1 2 3 -1 7 4 5 -1 5 6 7 -1 10 11 8 -1 8 9 10 -1 15 12 13 -1 13 14 15 -1 19 16 17 -1 17 18 19 -
        <TextureCoordinate DEF="pancreas_body-TEXCOORD" point="0.3216 0.7524, 0.3453 0.7017, 0.3897 0.7138, 0.3737 0.7668, 0.4972 0.4115, 0.4565 0.4139, 0.4542 0
        <Coordinate DEF="pancreas_body-COORD" point="-39.57 16.68 0.1025, -28.19 15.88 1.144, -27.88 7.437 3.637, -39.09 6.84 2.925, 29.93 0.8919 -2.553, 26.86 4.66
      </IndexedFaceSet>
    </Shape>
  </Transform>
  <Transform DEF="pancreas_head" translation="4.627 -2.169 -4.993">
    <Shape >
      <Appearance >
        <Material ambientIntensity="1.0" transparency="0.0" shininess="0.145" diffuseColor="0.588 0.588 0.588" specularColor="0.0 0.0 0.0"/>
        <ImageTexture url="pancreas.jpg"/>
      </Appearance>
      <IndexedFaceSet DEF="pancreas_head-FACES" coordIndex=" 3 0 1 -1 1 2 3 -1 7 4 5 -1 5 6 7 -1 8 9 6 -1 6 10 8 -1 11 12 13 -1 13 14 11 -1 15 16 17 -1 17 18 15 -1
        <TextureCoordinate DEF="pancreas_head-TEXCOORD" point="0.2051 0.1418, 0.2189 0.1131, 0.2549 0.1173, 0.232 0.1612, 0.2202 0.0819, 0.1941 0.053, 0.2303 0.0
        <Coordinate DEF="pancreas_head-COORD" point="-57.21 -22.62 27.23, -56.23 -31.04 31.06, -47.08 -30.94 25.35, -50.3 -21.86 21.55, -58.33 -35.7 24.25, -66.03
      </IndexedFaceSet>
    </Shape>
  </Transform>
```

Digestive System - Gallbladder



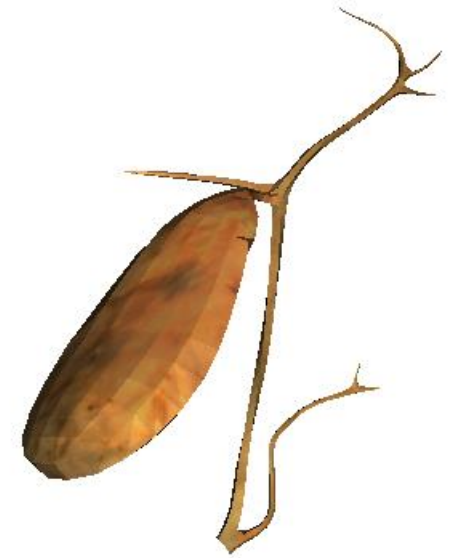
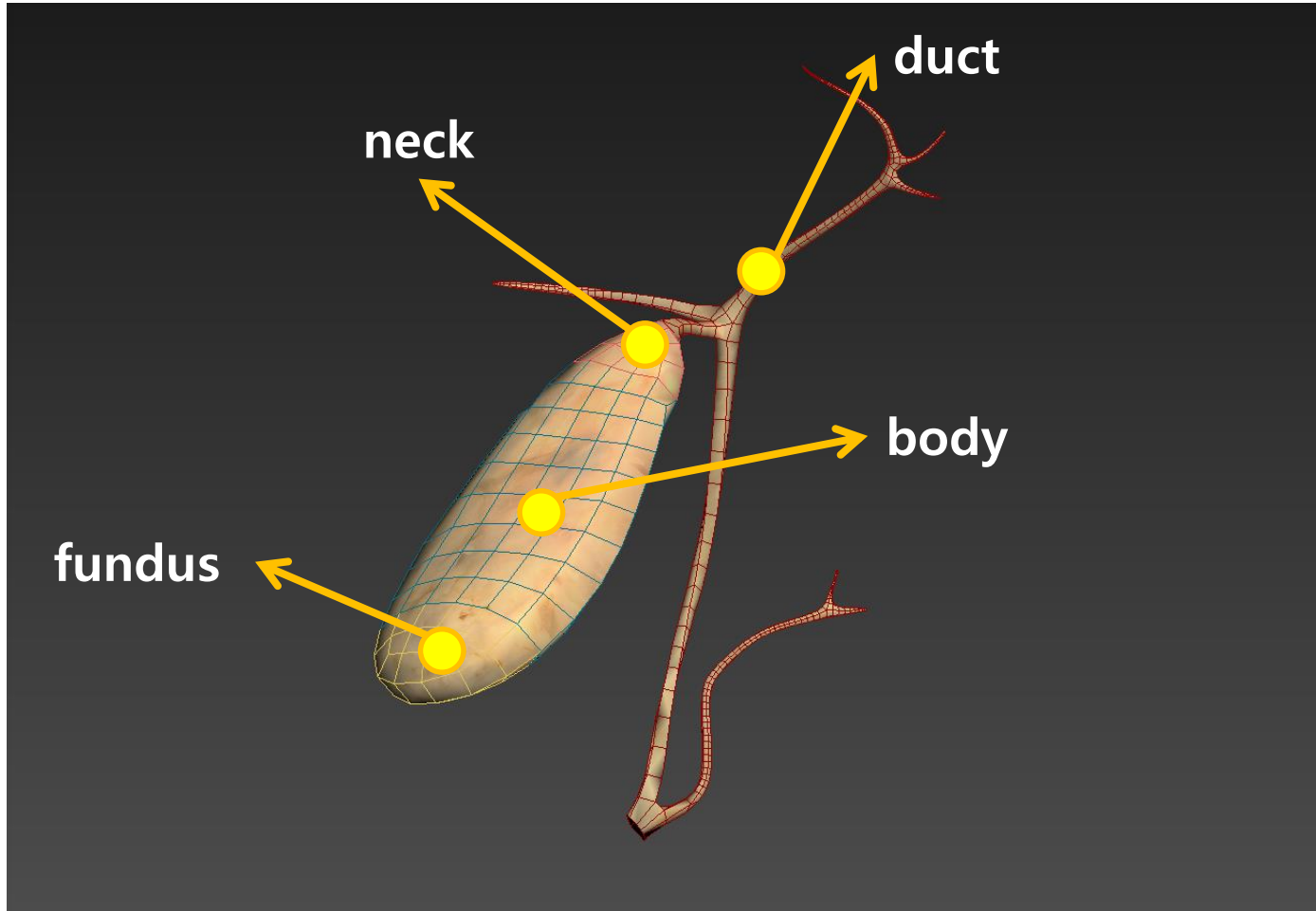
The gallbladder sits beneath the liver
<https://en.wikipedia.org/wiki/Gallbladder>

eHealthStar.com

http://www.innerbody.com/image_digeov/dige04-new.html

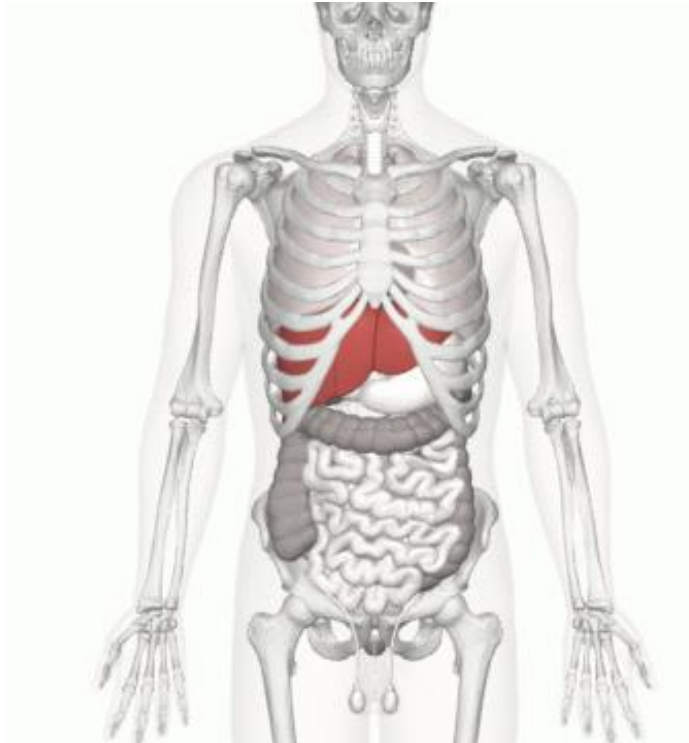
Gallbladder Modeling

3ds Max Viewport Shot

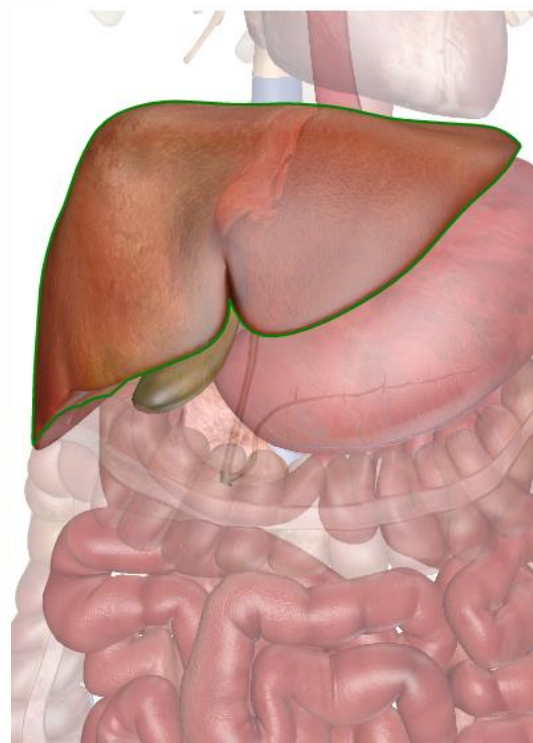


x3d Viewer Image

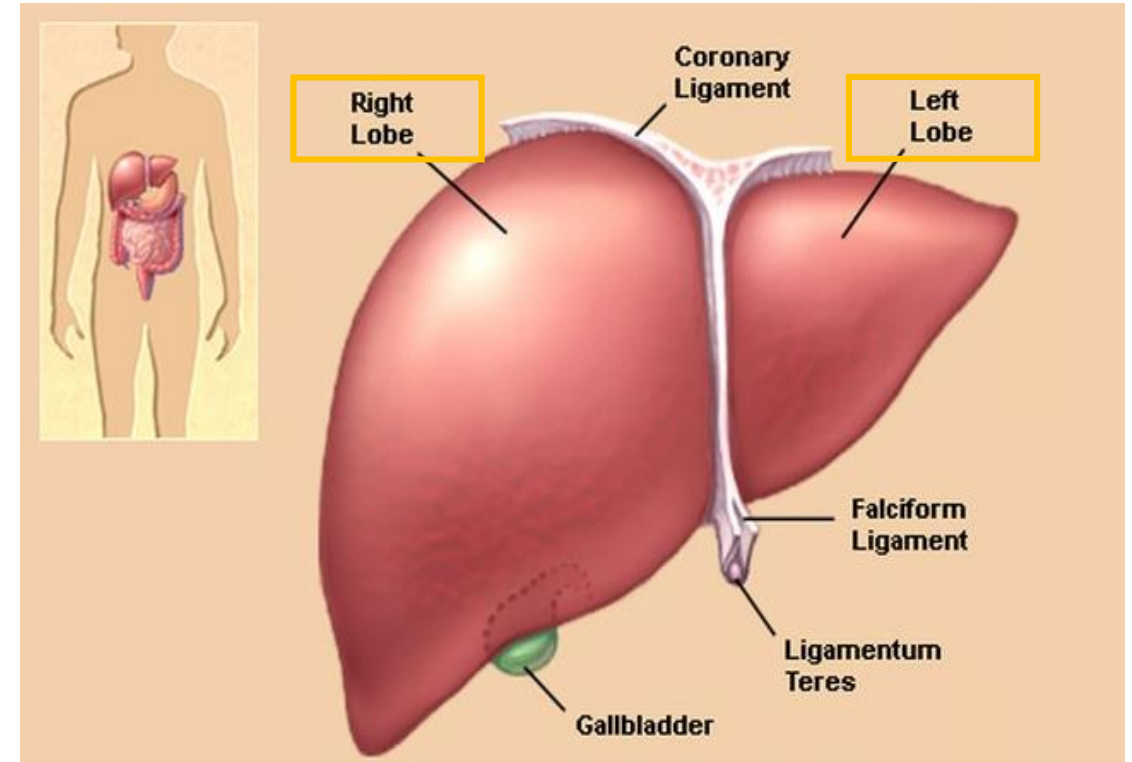
Digestive System - Liver



Location of human liver (in red)
<https://en.wikipedia.org/wiki/Liver>



<http://www.innerbody.com/image/digeov/card10-new2.html>

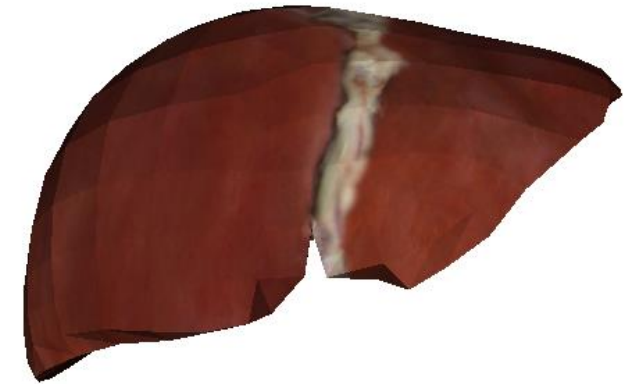
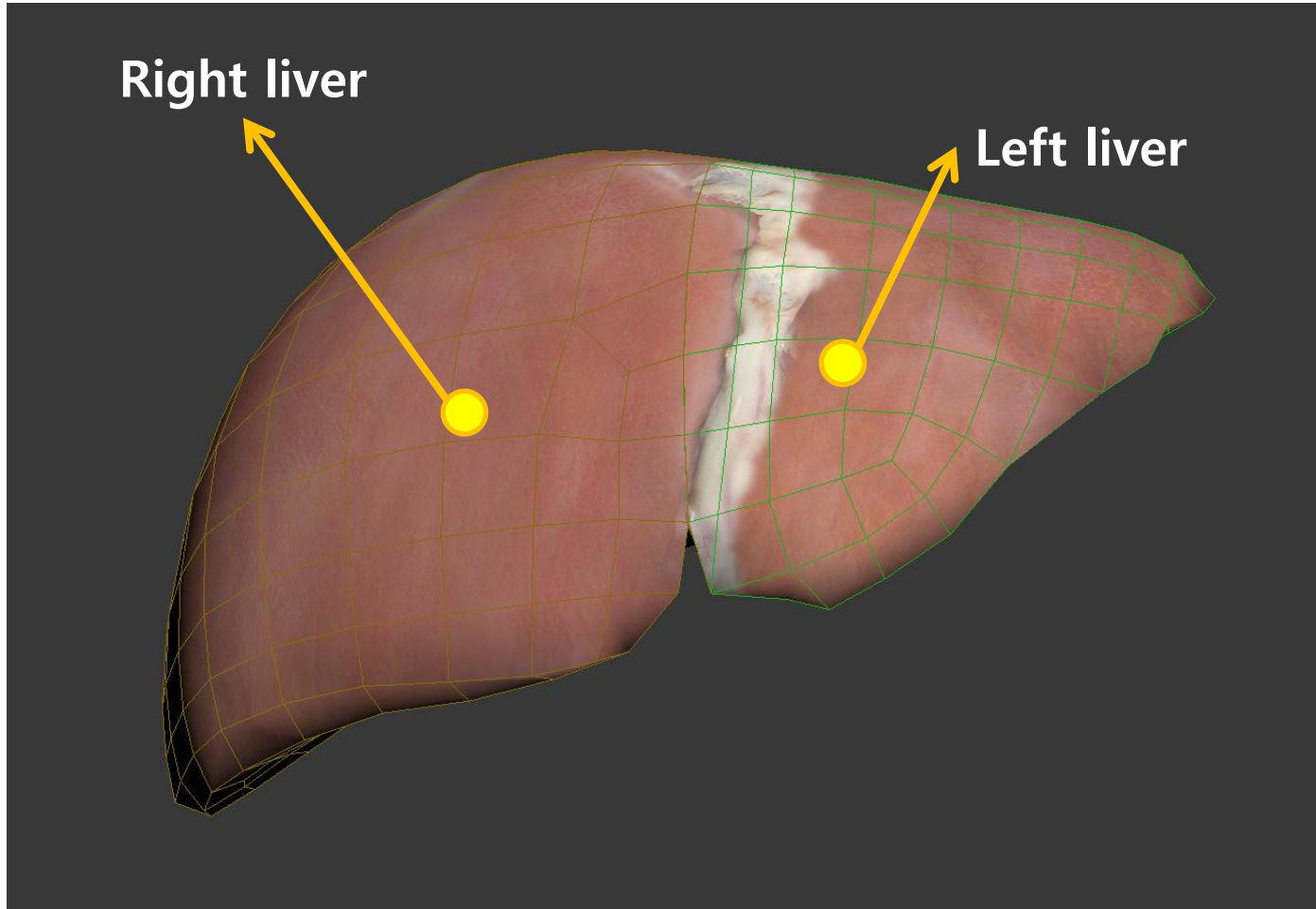


Sections of the human Liver

<https://www.webmd.com/digestive-disorders/picture-of-the-liver#1> / © 2014 WebMD, LLC. All rights reserved.

Liver Modeling

3ds Max Viewport Shot

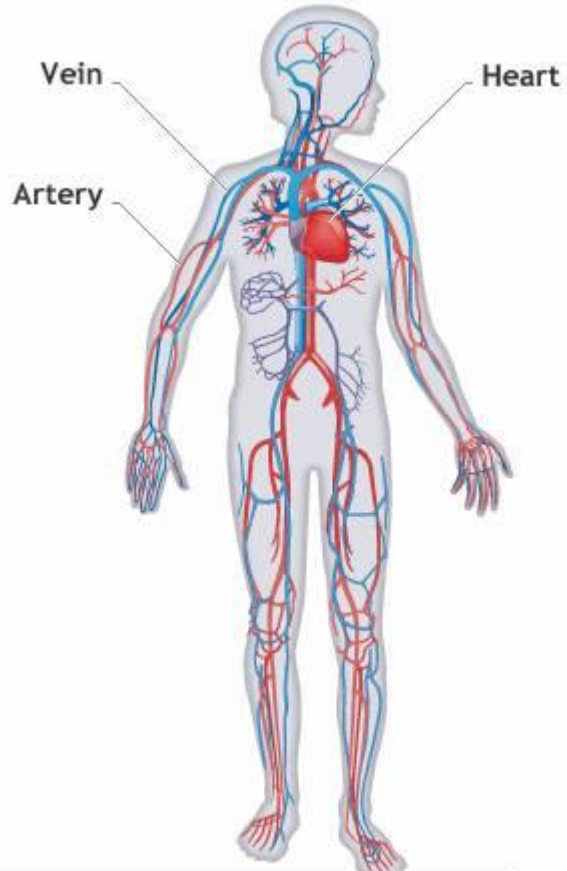


x3d Viewer Image

Liver X3D Structure

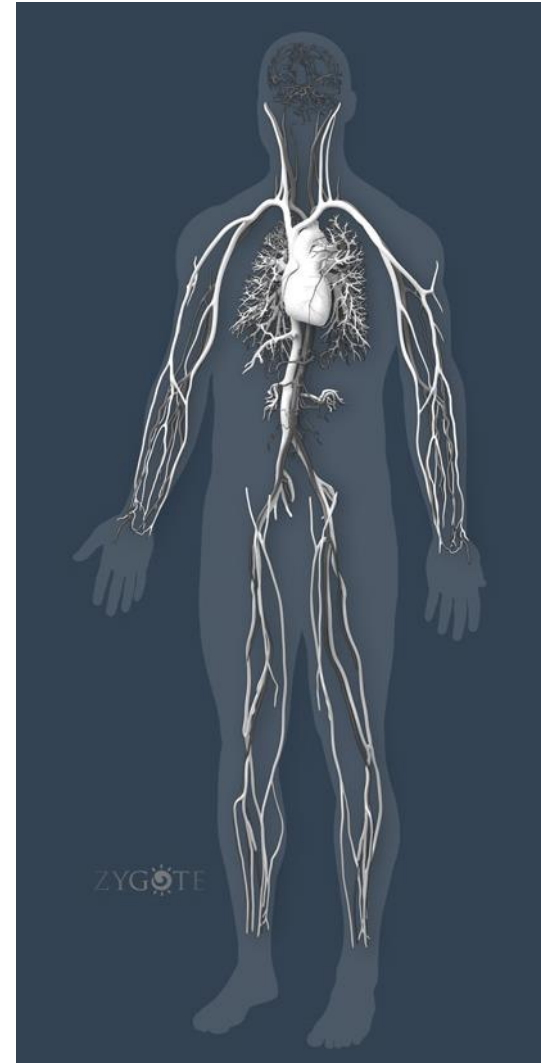
```
<?xml version='1.0' encoding='UTF-8'?>
<!DOCTYPE X3D PUBLIC "ISO//Web3D//DTD X3D 3.2//EN" "http://www.web3d.org/specifications/x3d-3.2.dtd">
<X3D version='3.2' profile='Immersive' xmlns:xsd='http://www.w3.org/2001/XMLSchema-instance' xsd:noNamespaceSchemaLocation='http://www.web3d.org/specification
<head>
  <meta name='title' content='Liver.x3d'/>
  <meta name='description' content='*enter description here, short-sentence summaries preferred*/>
  <meta name='creator' content='*enter name of original author here*/>
  <meta name='translator' content='*if manually translating VRML-to-X3D, enter name of person translating here*/>
  <meta name='created' content='*enter date of initial version here*/>
  <meta name='version' content='*enter version here*/>
  <meta name='reference' content='*enter reference citation or relative/online url here*/>
  <meta name='reference' content='*enter additional url/bibliographic reference information here*/>
  <meta name='requires' content='*enter reference resource here if required to support function, delivery, or coherence of content*/>
  <meta name='rights' content='*enter copyright information here* Example: Copyright (c) Web3D Consortium Inc. 2006*/>
  <meta name='drawing' content='*enter drawing filename/url here*/>
  <meta name='image' content='*enter image filename/url here*/>
  <meta name='MovingImage' content='*enter movie filename/url here*/>
  <meta name='photo' content='*enter photo filename/url here*/>
  <meta name='subject' content='*enter subject keywords here*/>
  <meta name='accessRights' content='*enter permission statements or url here*/>
  <meta name='warning' content='*insert any known warnings, bugs or errors here*/>
  <meta name='generator' content='Vrml97ToX3dNist, http://ovrt.nist.gov/v2_x3d.html'/>
  <meta name='generator' content='X3D-Edit, https://savage.nps.edu/X3D-Edit'/>
  <meta name='license' content='./../license.html'/>
</head>
<Scene>
  <Viewpoint position='0 0 500'/>
  <Background groundColor='1 1 1' skyColor='1 1 1'/>
  <Transform DEF="liver_right_lobe" translation="-59.16 -11.23 -14.76">
    <Shape >
      <Appearance >
        <Material ambientIntensity="1.0" transparency="0.0" shininess="0.145" diffuseColor="0.588 0.588 0.588" specularColor="0.0 0.0 0.0"/>
        <ImageTexture url="liver.jpg"/>
      </Appearance>
      <IndexedFaceSet DEF="liver_right_lobe-FACES" coordIndex="3 0 1 -1 1 2 3 -1 6 7 4 -1 4 5 6 -1 11 8 9 -1 9 10 11 -1 2 1 12 -1 12 13 2 -1 9 15 13 -1 13 14 9 -1 11 16 17 -1
        <TextureCoordinate DEF="liver_right_lobe-TEXCOORD" point="0.5106 0.9681, 0.4723 0.956, 0.4714 0.9262, 0.5197 0.9253, 0.4119 0.7147, 0.3625 0.7207, 0.3585 0.6745, 0
        <Coordinate DEF="liver_right_lobe-COORD" point="4.141 15.81 -77.97, 13.63 22.51 -67.86, 12.11 18.21 -57.48, -1.551 6.703 -64.19, 33.23 -10.37 10.18, 50.18 -3.288 10.1
      </IndexedFaceSet>
    </Shape>
  </Transform>
  <Transform DEF="liver_left_lobe" translation="59.42 12.42 14.6">
    <Shape >
      <Appearance >
        <Material ambientIntensity="1.0" transparency="0.0" shininess="0.145" diffuseColor="0.588 0.588 0.588" specularColor="0.0 0.0 0.0"/>
        <ImageTexture url="liver.jpg"/>
      </Appearance>
      <IndexedFaceSet DEF="liver_left_lobe-FACES" coordIndex="2 3 0 -1 0 1 2 -1 5 6 3 -1 3 4 5 -1 4 7 8 -1 8 9 4 -1 12 13 10 -1 10 11 12 -1 16 17 14 -1 14 15 16 -1 18 19 20 -
        <TextureCoordinate DEF="liver_left_lobe-TEXCOORD" point="0.2177 0.8336, 0.1918 0.8522, 0.1799 0.8252, 0.2131 0.8118, 0.2114 0.789, 0.2505 0.7841, 0.2482 0.8117, 0.1
        <Coordinate DEF="liver_left_lobe-COORD" point="-29.74 17.71 -42.5, -24.93 28.84 -48.82, -15.2 19.73 -48.82, -25.69 9.106 -46.54, -19.62 0.253 -43.89, -32.52 -5.944 -
      </IndexedFaceSet>
    </Shape>
  </Transform>
</Scene>
</X3D>
```

Circulatory System



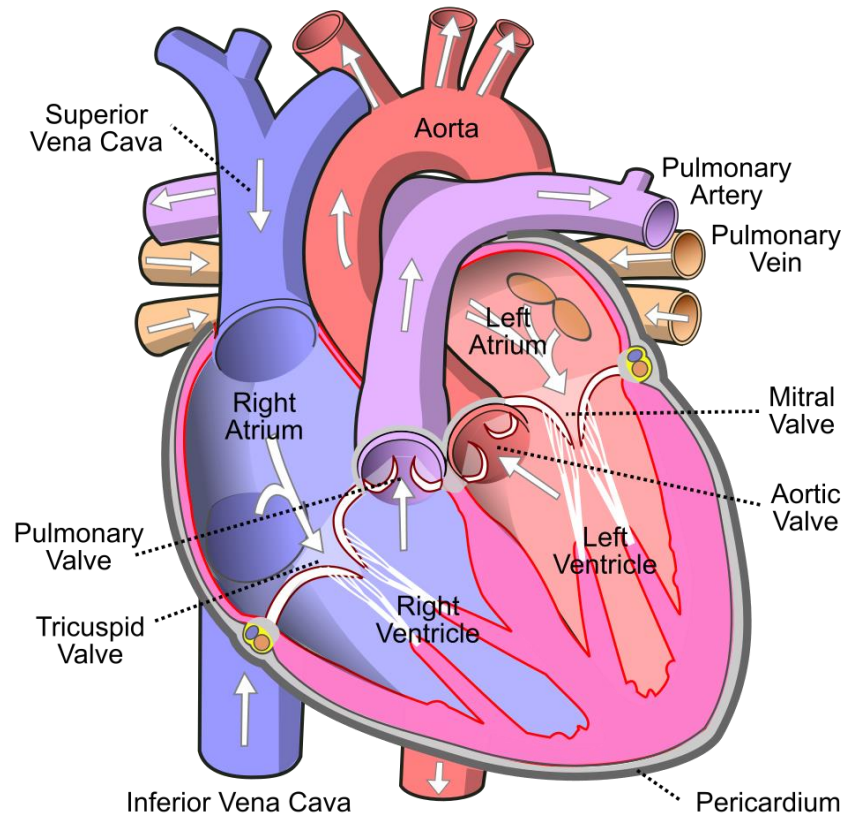
© Microsoft Corporation. All Rights Reserved.

<http://www.fit-ed.org/>



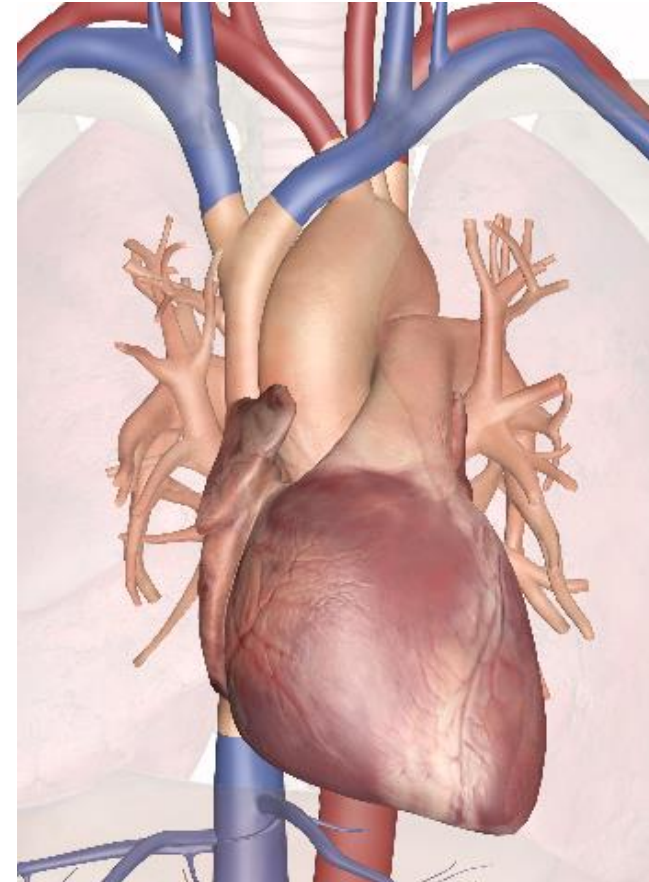
http://www.3dscience.com/3D_Models/Human_Anatomy/Solid_Models/solid-3d-human-anatomy-model-collection

Circulatory System - Heart



The heart, showing valves, arteries and veins. The white arrows show the normal direction of blood flow

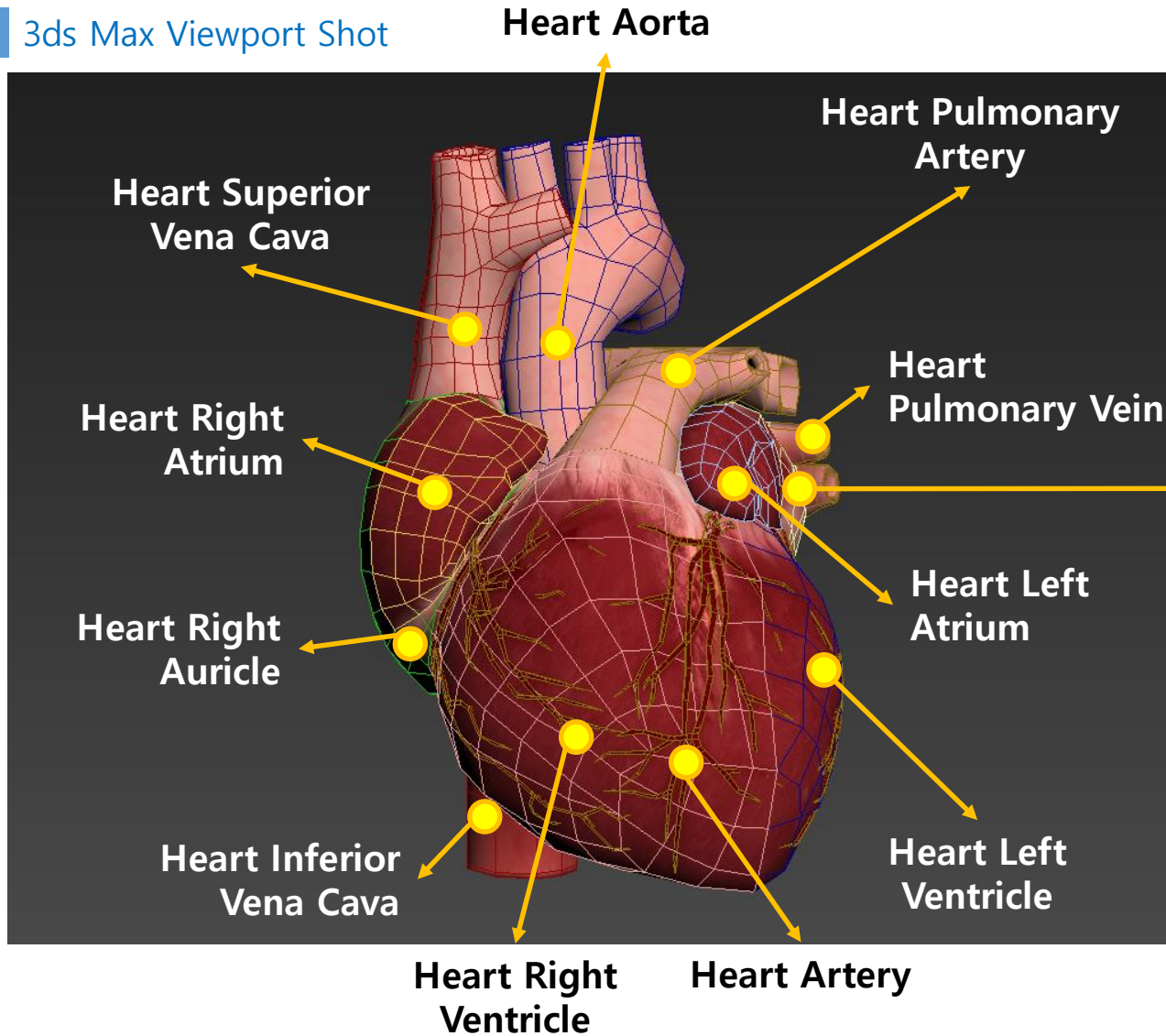
<https://en.wikipedia.org/wiki/Heart>



<https://www.innerbody.com/image/card01.html>

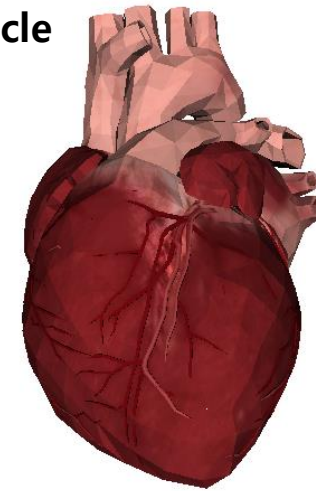
Heart Modeling

3ds Max Viewport Shot



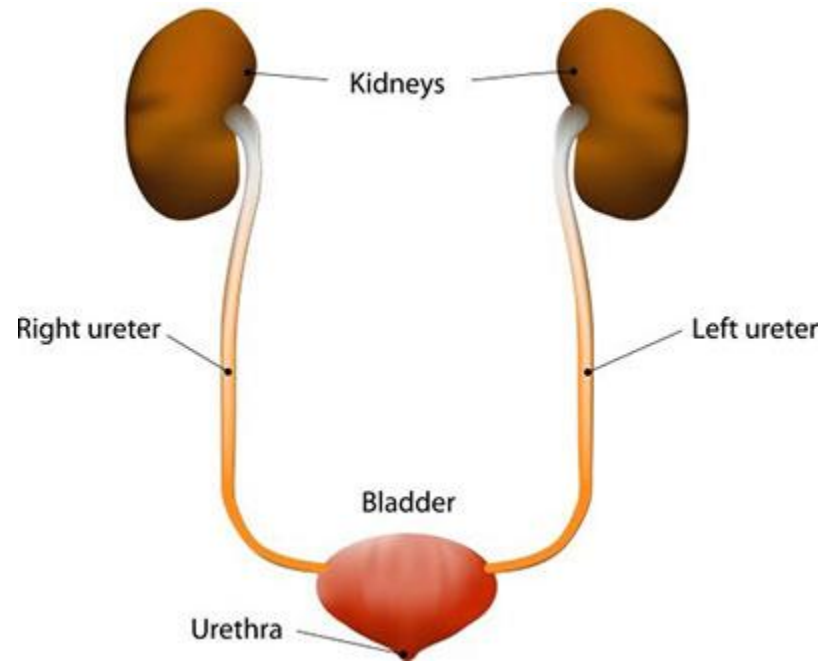
Rendering Image

Heart Left Auricle



x3d Viewer Image

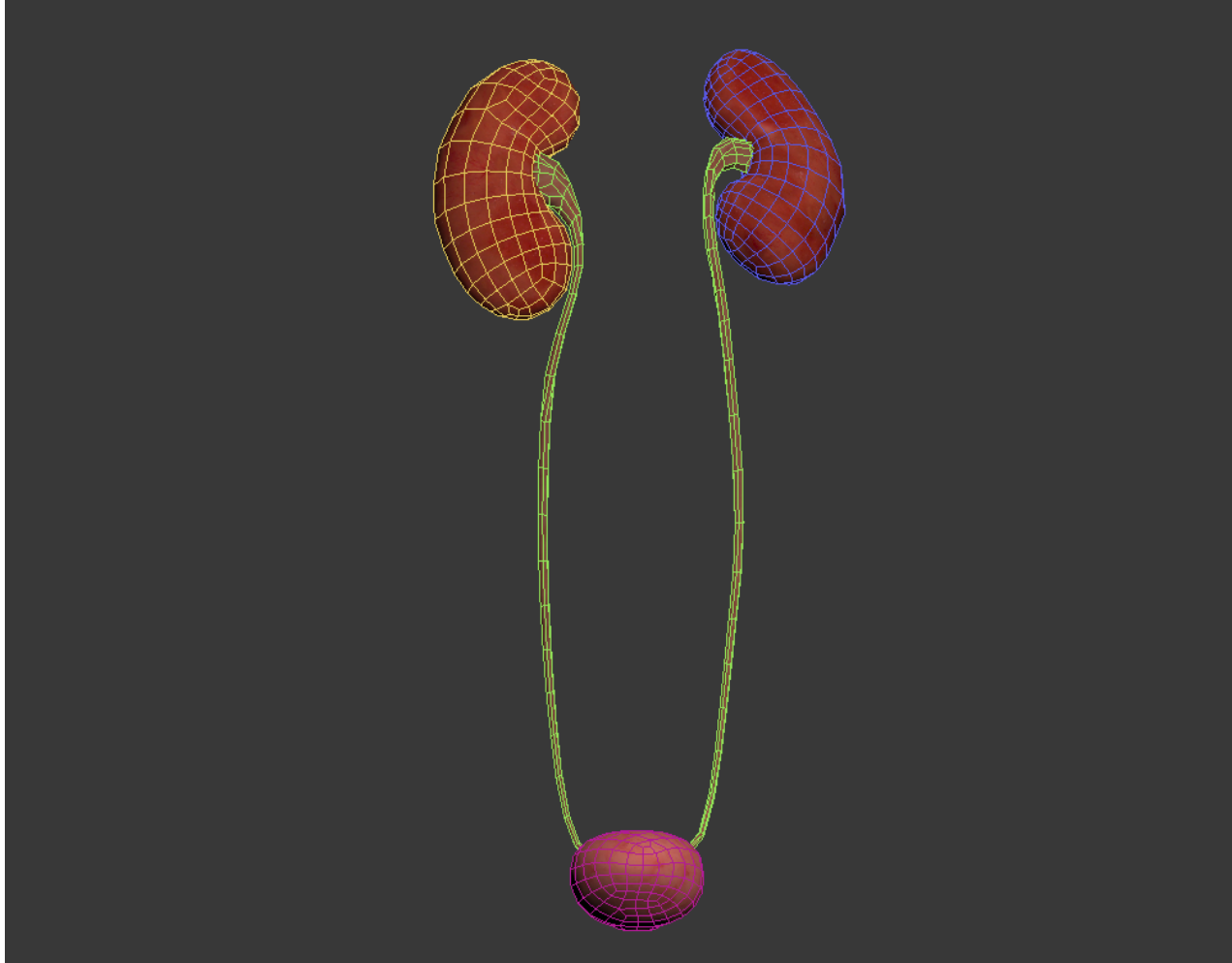
Urinary System



<https://www.cincinnatichildrens.org/health/u/urinary-system>

Urinary System Modeling

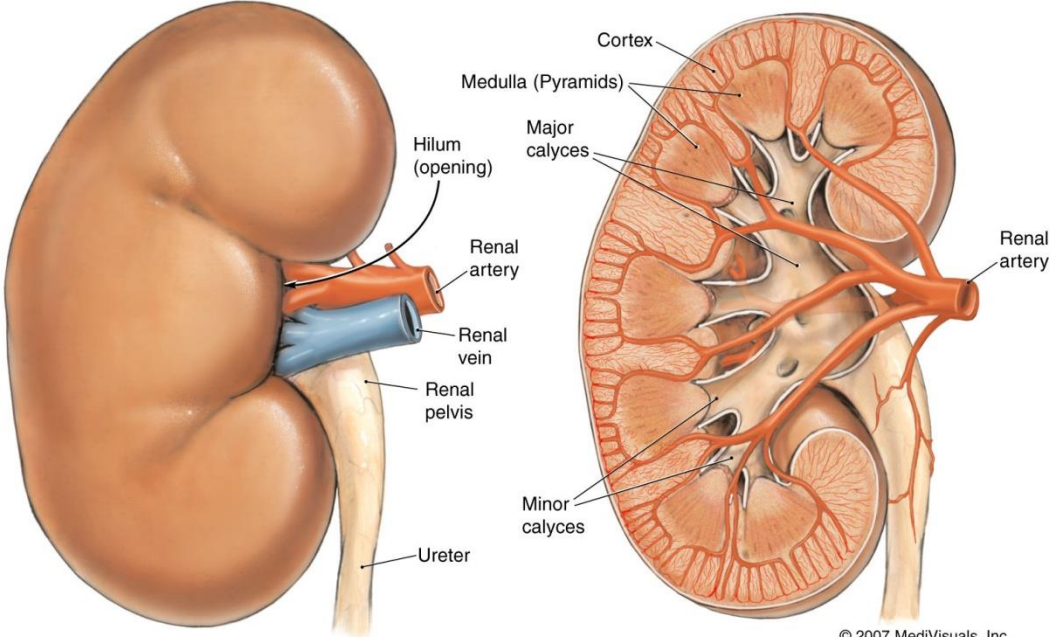
3ds Max Viewport Shot



x3d Viewer Image

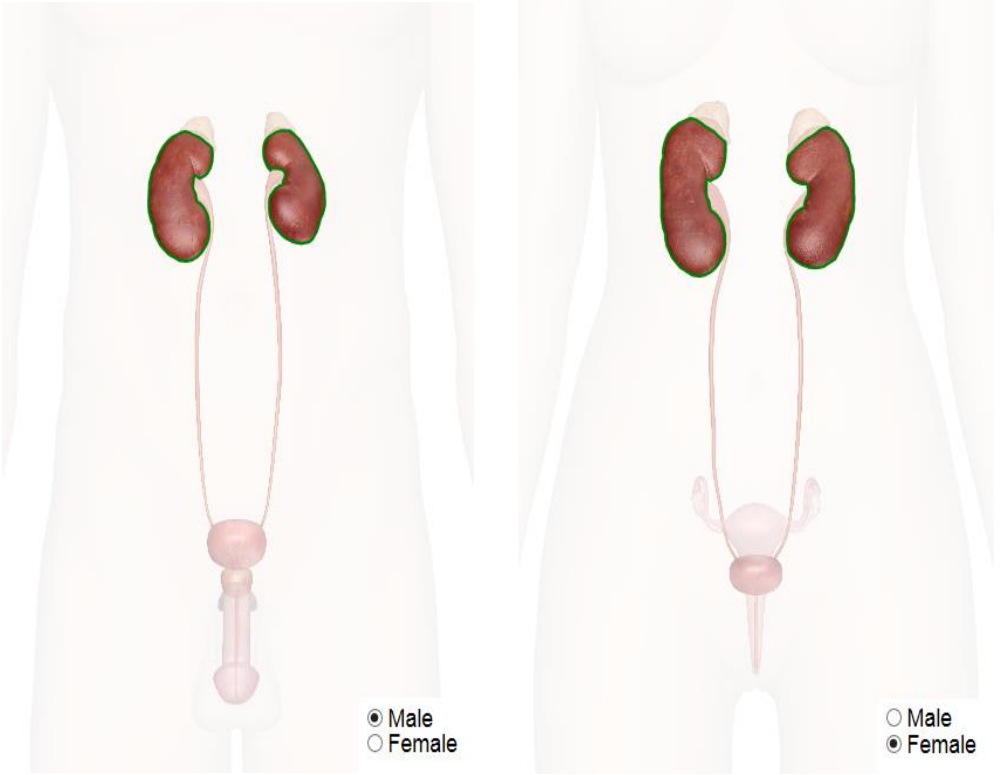
Urinary System - Kidney

The Right Kidney



BLOOD SUPPLY

INTERNAL STRUCTURE

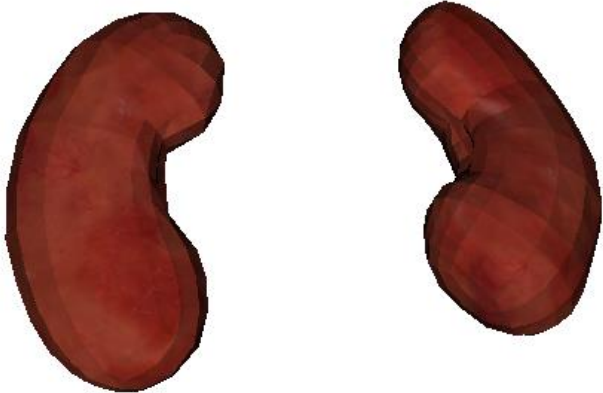
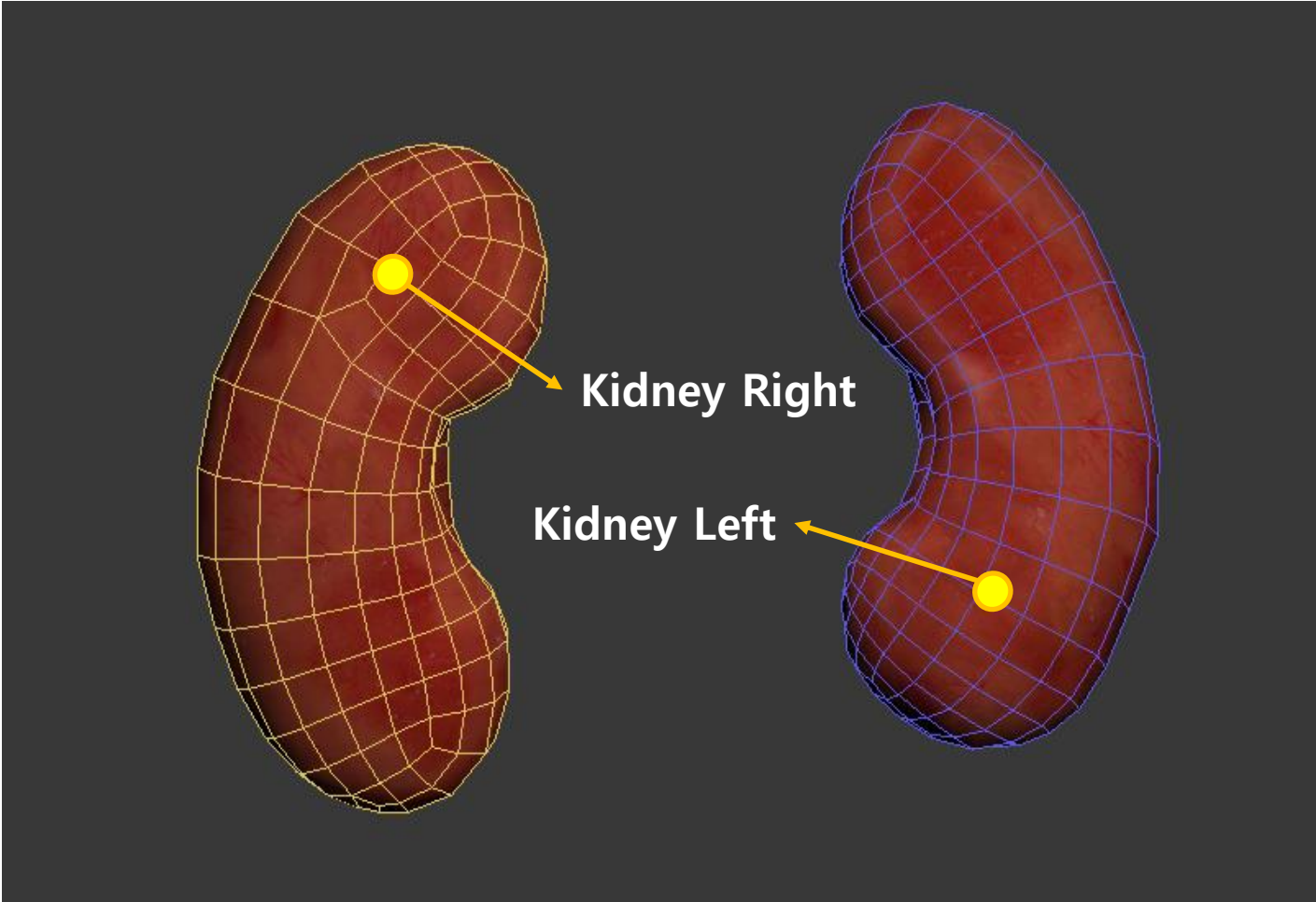


<https://therevealer.org/the-patient-body-whats-a-kidney-worth/>

https://www.innerbody.com/image_repo01/dige24-new.html

Kidney Modeling

3ds Max Viewport Shot

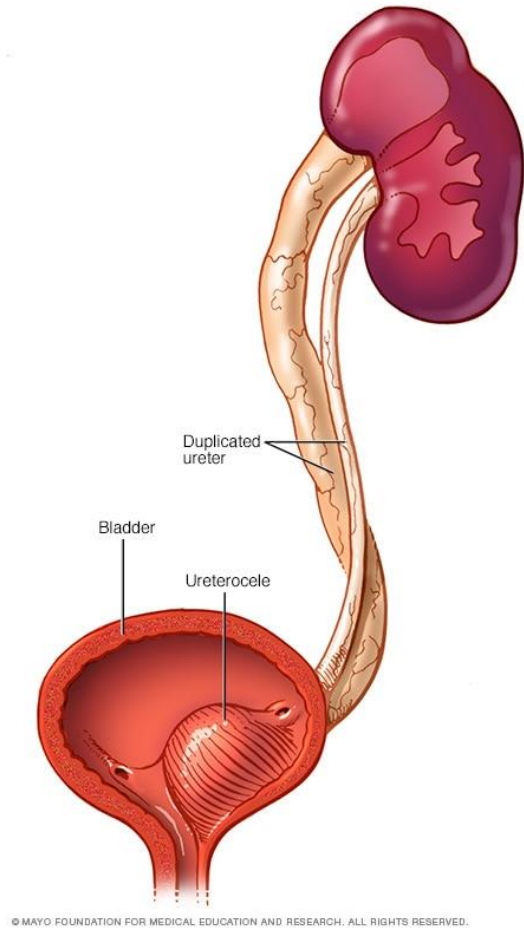


x3d Viewer Image

Kidney X3D Structure

```
<?xml version='1.0' encoding='UTF-8'?>
<!DOCTYPE X3D PUBLIC "ISO//Web3D//DTD X3D 3.3//EN" "http://www.web3d.org/specifications/x3d-3.3.dtd">
<X3D version='3.3' profile='Immersive' xmlns:xsd='http://www.w3.org/2001/XMLSchema-instance' xsd:noNamespaceSchemaLocation='http://www.web3d.org/specificator
<head>
  <meta name='title' content='Kidney.x3d' />
  <meta name='description' content='*enter description here, short-sentence summaries preferred*/>
  <meta name='creator' content='*enter name of original author here*/>
  <meta name='translator' content='*if manually translating VRML-to-X3D, enter name of person translating here*/>
  <meta name='created' content='*enter date of initial version here*/>
  <meta name='version' content='*enter version here*/>
  <meta name='reference' content='*enter reference citation or relative/online url here*/>
  <meta name='reference' content='*enter additional url/bibliographic reference information here*/>
  <meta name='requires' content='*enter reference resource here if required to support function, delivery, or coherence of content*/>
  <meta name='rights' content='*enter copyright information here* Example: Copyright (c) Web3D Consortium Inc. 2006*/>
  <meta name='drawing' content='*enter drawing filename/url here*/>
  <meta name='image' content='*enter image filename/url here*/>
  <meta name='MovingImage' content='*enter movie filename/url here*/>
  <meta name='photo' content='*enter photo filename/url here*/>
  <meta name='subject' content='*enter subject keywords here*/>
  <meta name='accessRights' content='*enter permission statements or url here*/>
  <meta name='warning' content='*insert any known warnings, bugs or errors here*/>
  <meta name='generator' content='Vrml97ToX3dNist, http://ovrt.nist.gov/v2_x3d.html' />
  <meta name='generator' content='X3D-Edit, https://savage.nps.edu/X3D-Edit' />
  <meta name='license' content='..././license.html' />
</head>
<Scene>
  <Viewpoint position='0 0 0.5' />
  <Background groundColor='1 1 1' skyColor='1 1 1' />
  <Transform DEF="Kidney_Right" translation="-0.05388 -0.004601 0.005788">
    <Shape >
      <Appearance >
        <Material ambientIntensity="1.0" transparency="0.0" shininess="0.145" diffuseColor="0.588 0.588 0.588" specularColor="0.0 0.0 0.0"/>
        <ImageTexture url="kidneys.jpg"/>
      </Appearance>
      <IndexedFaceSet DEF="Kidney_Right-FACES" coordIndex=" 0 1 2 -1 2 3 0 -1 4 5 6 -1 6 7 4 -1 8 9 10 -1 10 11 8 -1 8 11 12 -1 12 13 8 -1 14 15 16 -1 16 17 14 -1 18 19 20
        <TextureCoordinate DEF="Kidney_Right-TEXCOORD" point="0.492 0.6083, 0.4697 0.6066, 0.4698 0.6228, 0.4868 0.6298, 0.5659 0.5082, 0.5371 0.5184, 0.5458 0.5453, 0.5
        <Coordinate DEF="Kidney_Right-COORD" point="0.005598 0.05194 -0.01834, 0.011 0.05224 -0.02144, 0.008298 0.05094 -0.02444, 0.003699 0.05044 -0.02364, 0.003599 (
      </IndexedFaceSet>
    </Shape>
  </Transform>
  <Transform DEF="Kidney_Left" translation="0.05389 0.004598 -0.005808">
    <Shape >
      <Appearance >
        <Material ambientIntensity="1.0" transparency="0.0" shininess="0.145" diffuseColor="0.588 0.588 0.588" specularColor="0.0 0.0 0.0"/>
        <ImageTexture url="kidneys.jpg"/>
      </Appearance>
      <IndexedFaceSet DEF="Kidney_Left-FACES" coordIndex=" 0 1 2 -1 2 3 0 -1 4 0 3 -1 3 5 4 -1 6 7 8 -1 8 4 6 -1 6 4 5 -1 5 9 6 -1 10 11 12 -1 12 13 10 -1 14 15 16 -1 16 17 1
        <TextureCoordinate DEF="Kidney_Left-TEXCOORD" point="0.3194 0.6935, 0.3097 0.6868, 0.3249 0.6592, 0.3302 0.682, 0.3195 0.7134, 0.3317 0.6987, 0.3353 0.7246, 0.328
        <Coordinate DEF="Kidney_Left-COORD" point="-0.006898 -4.517E-4 0.01015, -0.009997 -0.001851 0.009647, -0.0119 -0.004251 0.01605, -0.009097 -1.523E-4 0.01355, -
      </IndexedFaceSet>
    </Shape>
  </Transform>
</Scene>
</X3D>
```

Urinary System - Ureter



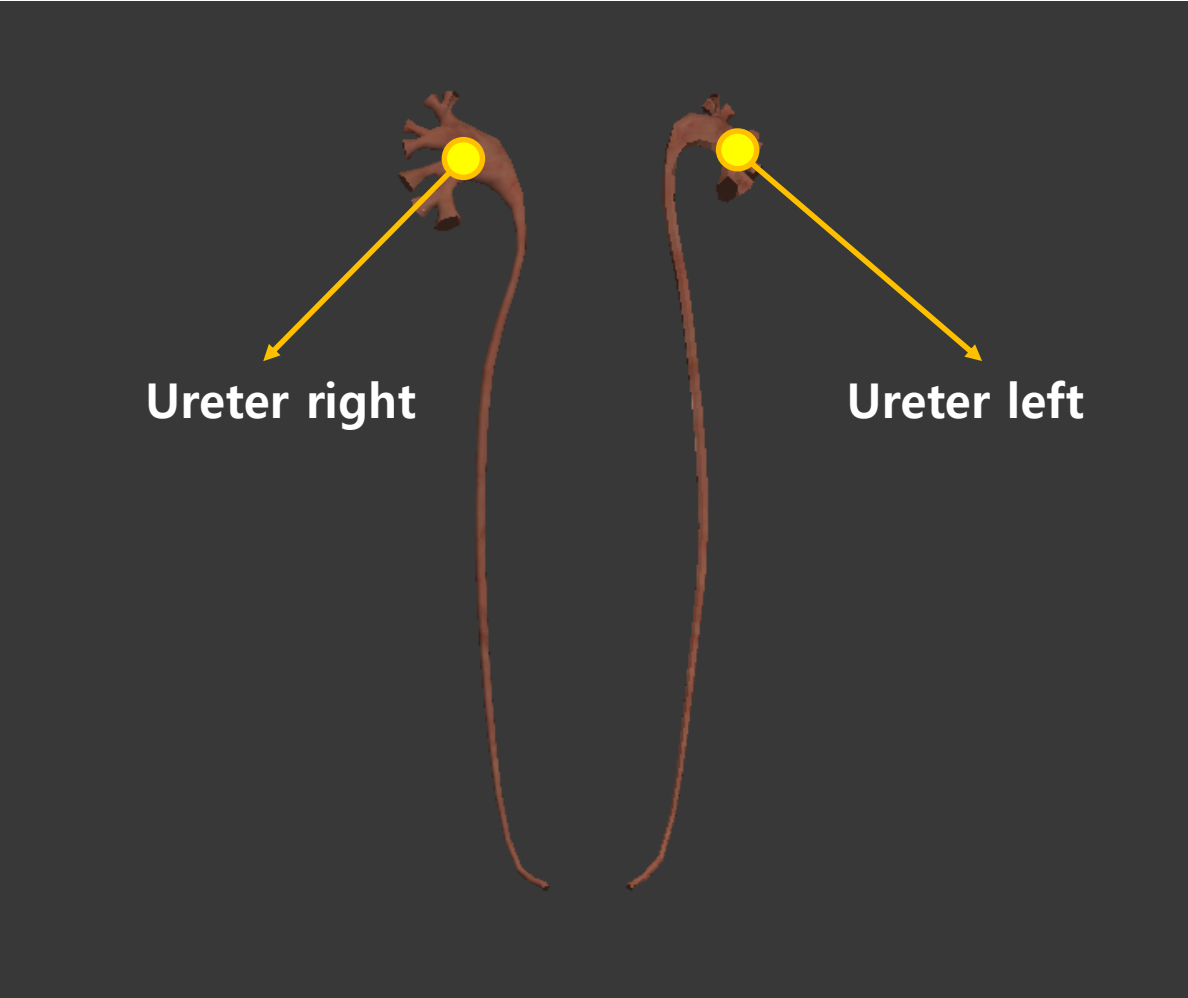
<https://www.mayoclinic.org/>



https://www.innerbody.com/image_urinov/repo15-new2.html

Ureter Modeling

3ds Max Viewport Shot

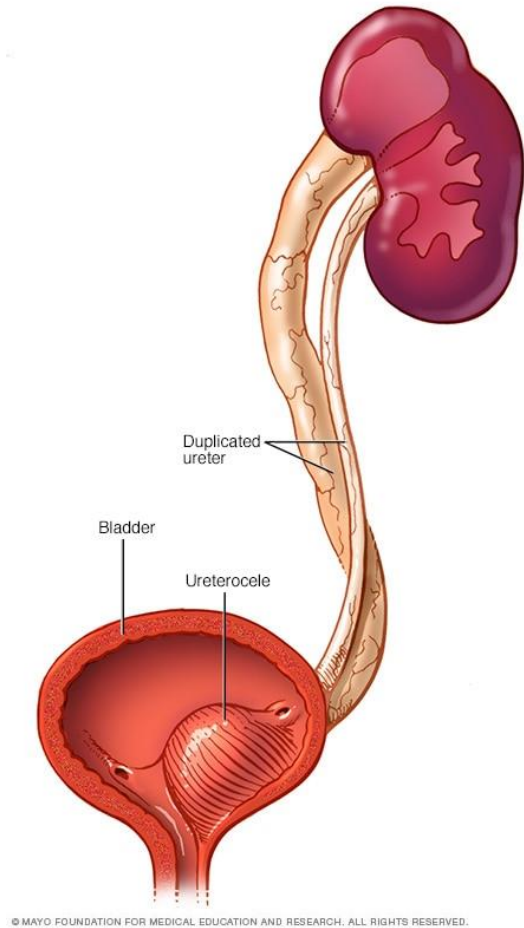


x3d Viewer Image

Ureter X3D Structure

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<?xml version='1.0' encoding='UTF-8'?>
<!DOCTYPE X3D PUBLIC "ISO//Web3D//DTD X3D 3.3//EN" "http://www.web3d.org/specifications/x3d-3.3.dtd">
<X3D version="3.3" profile="Immersive" xmlns:xsd="http://www.w3.org/2001/XMLSchema-instance" xsd:noNamespaceSchemaLocation="http://www.web3d.org/specificat
<head>
  <meta name="title" content="Ureter.x3d"/>
  <meta name="description" content="*enter description here, short-sentence summaries preferred*/>
  <meta name="creator" content="*enter name of original author here*/>
  <meta name="translator" content="*if manually translating VRML-to-X3D, enter name of person translating here*/>
  <meta name="created" content="*enter date of initial version here*/>
  <meta name="version" content="*enter version here*/>
  <meta name="reference" content="*enter reference citation or relative/online url here*/>
  <meta name="reference" content="*enter additional url/bibliographic reference information here*/>
  <meta name="requires" content="*enter reference resource here if required to support function, delivery, or coherence of content*/>
  <meta name="rights" content="*enter copyright information here+ Example: Copyright (c) Web3D Consortium Inc. 2006*/>
  <meta name="drawing" content="*enter drawing filename/url here*/>
  <meta name="image" content="*enter image filename/url here*/>
  <meta name="MovingImage" content="*enter movie filename/url here*/>
  <meta name="photo" content="*enter photo filename/url here*/>
  <meta name="subject" content="*enter subject keywords here*/>
  <meta name="accessRights" content="*enter permission statements or url here*/>
  <meta name="warning" content="*insert any known warnings, bugs or errors here*/>
  <meta name="generator" content="Vrml97ToX3dNist, http://ovrt.nist.gov/v2_x3d.html"/>
  <meta name="generator" content="X3D-Edit, https://savage.nps.edu/X3D-Edit"/>
  <meta name="license" content=".././license.html"/>
</head>
<Scene>
  <Viewpoint position="0 0 0.5"/>
  <Background groundColor="1 1 1" skyColor="1 1 1"/>
  <Transform DEF="Ureter_right" translation="-0.03902 2.613E-4 8.431E-4">
    <Shape >
      <Appearance >
        <Material ambientIntensity="1.0" transparency="0.0" shininess="0.145" diffuseColor="0.588 0.588 0.588" specularColor="0.0 0.0 0.0"/>
        <ImageTexture url="kidneys.jpg"/>
      </Appearance>
      <IndexedFaceSet DEF="Ureter_right-FACES" coordIndex="0 1 2 -1 2 3 0 -1 4 5 1 -1 1 0 4 -1 6 2 1 -1 7 8 5 -1 5 4 7 -1 6 1 9 -1 9 10 6 -1 1 5 9 -1 7 11 12 -1 12 8 7 -1 1 1:
        <TextureCoordinate DEF="Ureter_right-TEXCOORD" point="0.1048 0.07738, 0.1041 0.07801, 0.07709 0.08209, 0.07778 0.0814, 0.1394 0.07261, 0.1394 0.07399, 0.07847
        <Coordinate DEF="Ureter_right-COORD" point="0.007581 -0.1154 -0.01881, 0.007934 -0.1159 -0.02022, 0.01122 -0.1325 -0.01892, 0.01099 -0.1319 -0.01763, 0.00546
      </IndexedFaceSet>
    </Shape>
  </Transform>
  <Transform DEF="Ureter_Left" translation="0.03902 -2.678E-4 -8.612E-4">
    <Shape >
      <Appearance >
        <Material ambientIntensity="1.0" transparency="0.0" shininess="0.145" diffuseColor="0.588 0.588 0.588" specularColor="0.0 0.0 0.0"/>
        <ImageTexture url="kidneys.jpg"/>
      </Appearance>
      <IndexedFaceSet DEF="Ureter_Left-FACES" coordIndex="0 1 2 -1 2 3 0 -1 4 5 1 -1 1 0 4 -1 1 6 7 -1 7 2 1 -1 9 5 4 -1 4 8 9 -1 10 6 1 -1 1 5 10 -1 7 6 11 -1 11 12 7 -1 9
        <TextureCoordinate DEF="Ureter_Left-TEXCOORD" point="0.629 0.08579, 0.6025 0.0824, 0.6019 0.08379, 0.6283 0.08718, 0.6303 0.08309, 0.6032 0.0797, 0.5674 0.0790
        <Coordinate DEF="Ureter_Left-COORD" point="-0.008051 -0.1206 -0.01616, -0.005465 -0.1037 -0.01346, -0.006406 -0.1037 -0.01475, -0.008756 -0.1208 -0.01734, -0
      </IndexedFaceSet>
    </Shape>
  </Transform>
</Scene>
</X3D>
```

Urinary System - Bladder



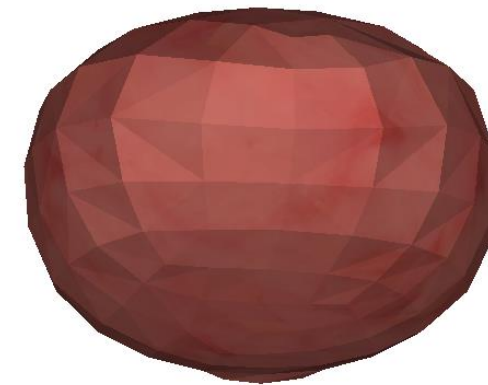
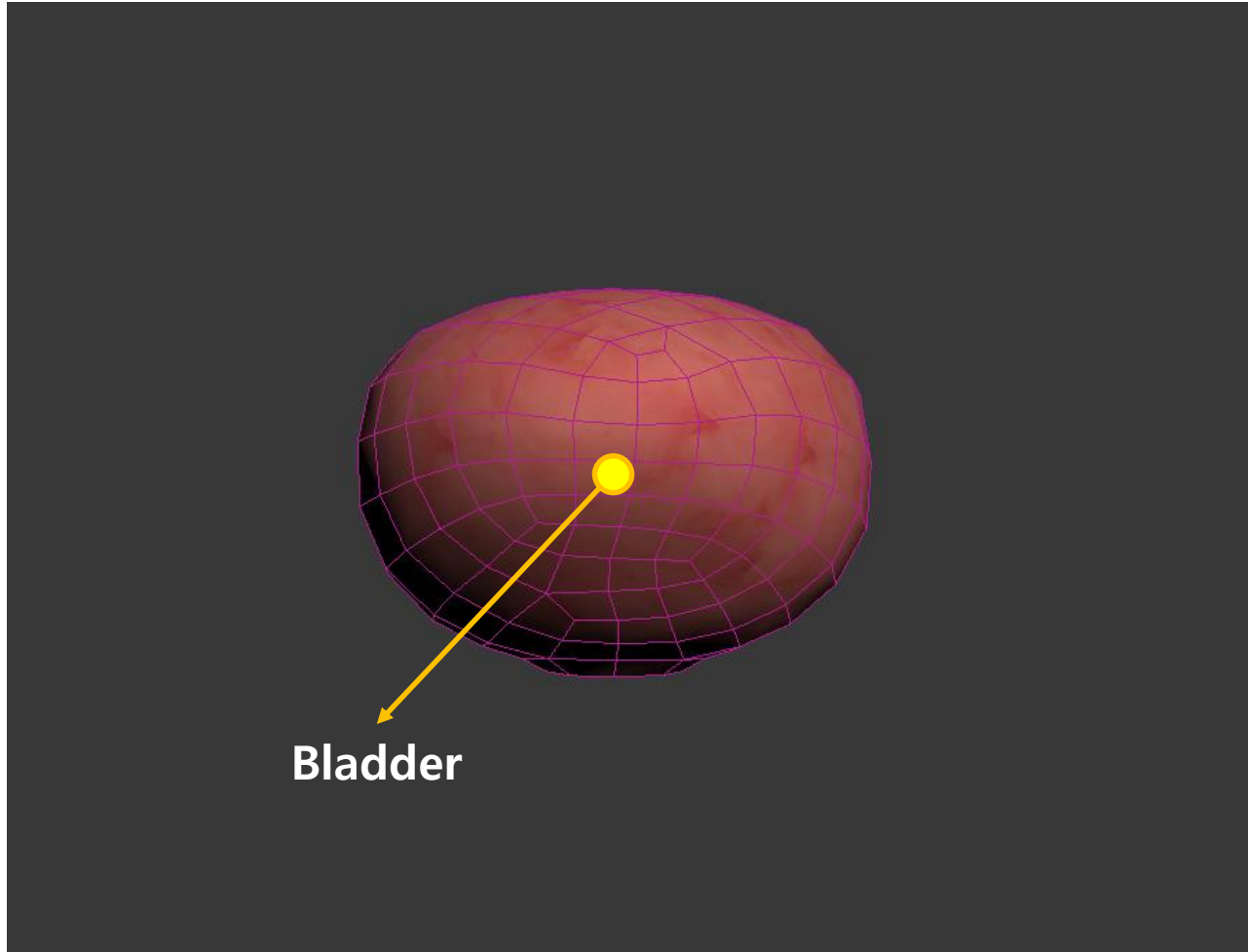
<https://www.mayoclinic.org/>



https://www.innerbody.com/image_urinov/repo15-new2.html

Bladder Modeling

3ds Max Viewport Shot



x3d Viewer Image

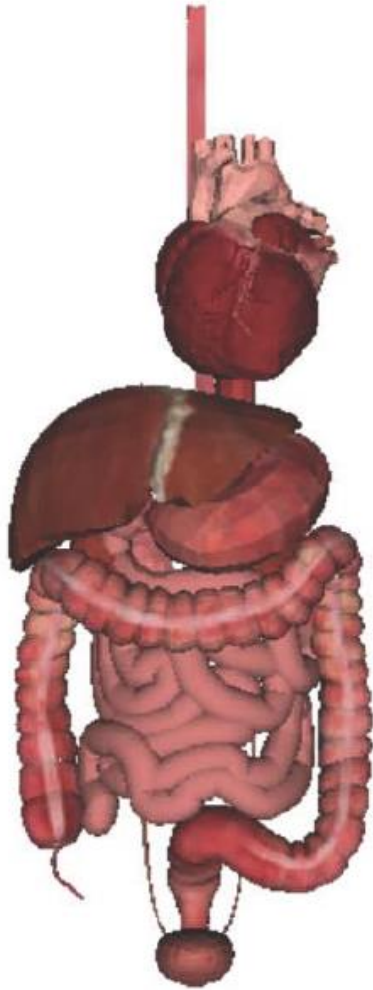
Bladder X3D Structure

```
<?xml version='1.0' encoding='UTF-8'?>
<!DOCTYPE X3D PUBLIC "ISO//Web3D//DTD X3D 3.3//EN" "http://www.web3d.org/specifications/x3d-3.3.dtd">
<X3D version='3.3' profile='Immersive' xmlns:xsd='http://www.w3.org/2001/XMLSchema-instance' xsd:noNamespaceSchemaLocation='http://www.web3d.org/s
<head>
  <meta name='title' content='Bladder.x3d'/>
  <meta name='description' content='*enter description here, short-sentence summaries preferred*/>
  <meta name='creator' content='*enter name of original author here*/>
  <meta name='translator' content='*if manually translating VRML-to-X3D, enter name of person translating here*/>
  <meta name='created' content='*enter date of initial version here*/>
  <meta name='version' content='*enter version here*/>
  <meta name='reference' content='*enter reference citation or relative/online url here*/>
  <meta name='reference' content='*enter additional url/bibliographic reference information here*/>
  <meta name='requires' content='*enter reference resource here if required to support function, delivery, or coherence of content*/>
  <meta name='rights' content='*enter copyright information here* Example: Copyright (c) Web3D Consortium Inc. 2006*/>
  <meta name='drawing' content='*enter drawing filename/url here*/>
  <meta name='image' content='*enter image filename/url here*/>
  <meta name='MovingImage' content='*enter movie filename/url here*/>
  <meta name='photo' content='*enter photo filename/url here*/>
  <meta name='subject' content='*enter subject keywords here*/>
  <meta name='accessRights' content='*enter permission statements or url here*/>
  <meta name='warning' content='*insert any known warnings, bugs or errors here*/>
  <meta name='generator' content='Vrml97ToX3dNist, http://ovrt.nist.gov/v2_x3d.html'/>
  <meta name='generator' content='X3D-Edit, https://savage.nps.edu/X3D-Edit'/>
  <meta name='license' content='../license.html'/>
</head>
<Scene>
  <Viewpoint position='0 0.05 0.5'/>
  <Background groundColor='1 1 1' skyColor='1 1 1'/>
  <Transform DEF="Bladder" translation="0.0 0.0 0.0">
    <Shape >
      <Appearance >
        <Material ambientIntensity="1.0" transparency="0.0" shininess="0.145" diffuseColor="0.588 0.588 0.588" specularColor="0.0 0.0 0.0"/>
        <ImageTexture url="kidneys.jpg"/>
      </Appearance>
      <IndexedFaceSet DEF="Bladder-FACES" coordIndex="0 1 2 -1 2 3 0 -1 4 5 6 -1 6 7 4 -1 9 10 11 -1 11 8 9 -1 13 14 15 -1 15 12 13 -1 19 16 17 -1 17 18 19 -1 ;
        <TextureCoordinate DEF="Bladder-TEXCOORD" point="0.9677 0.05719, 0.955 0.06387, 0.9409 0.04799, 0.9521 0.03964, 0.606 0.202, 0.6113 0.2087, 0.608 0.2
        <Coordinate DEF="Bladder-COORD" point="0.02328 0.005796 0.01047, 0.02121 0.01237 0.01026, 0.01669 0.01312 0.01804, 0.01943 0.006964 0.01812, 0.00415
      </IndexedFaceSet>
    </Shape>
  </Transform>
</Scene>
</X3D>
```

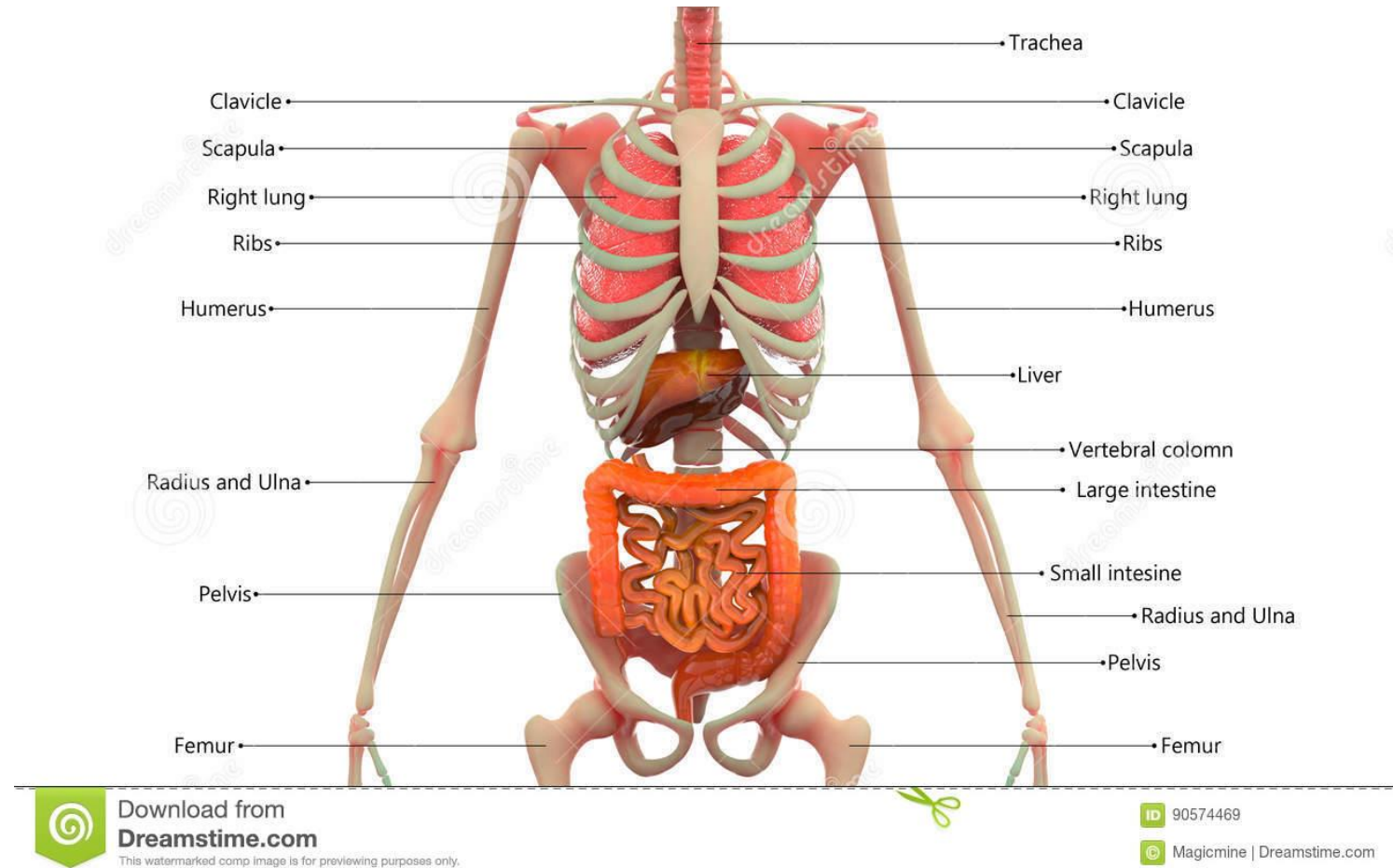
X3D Structure

```
<internal organ>
  <digestive>
    <Transform DEF="Esophagus">
      <Shape>
        <IndexedFaceSet DEF="Esophagus-FACES" coordindex"...">
          <TextureCoordinate EDF="Esophagus-TEXCOORD" point="...">
            <Coordinate DEF="Esophagus-COORD" point="...">
          </IndexedFaceSet>
        </Shape>
      </Transform>
    <Transform DEF="Stomach">
      <Shape>
        <IndexedFaceSet DEF="Stomach-FACES" coordindex"...">
          <TextureCoordinate EDF="Stomach-TEXCOORD" point="...">
            <Coordinate DEF="Stomach-COORD" point="...">
          </IndexedFaceSet>
        </Shape>
      </Transform>
    <Transform DEF="Duodenum">
      <Shape>
        <IndexedFaceSet DEF="Duodenum-FACES" coordindex"...">
          <TextureCoordinate EDF="Duodenum-TEXCOORD" point="...">
            <Coordinate DEF="Duodenum-COORD" point="...">
          </IndexedFaceSet>
        </Shape>
      </Transform>
    <Transform DEF="Small Intestine">
      <Shape>
        <IndexedFaceSet DEF="Small Intestine-FACES" coordindex"...">
          <TextureCoordinate EDF="Small Intestine-TEXCOORD" point="...">
            <Coordinate DEF="Small Intestine-COORD" point="...">
          </IndexedFaceSet>
        </Shape>
      </Transform>
```

Integration of Internal Organs



Internal_Organs.x3d



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Internal organs data model

- Modeling
 - Organ
 - Regions
 - Region name
 - Region meta interface
 - Geometry
 - Appearance
 - Layers
 - Layer name
 - Layer meta interface
 - Geometry
 - Appearance
- Animation
 - Region based keyframe animation
 - Region based motion data animation

Level of details for representation

- Based on eye investigation (microscopy?)
- LOD 1
 - Organ level representation (stomach, liver, ..)
- LOD 2
 - Region level representation for each organ
- LOD 3
 - Layer representation

Conclusions (1)

- Representation data model for human internal organs
 - Modeling data model
 - Animation data model
 - Interface data model with medical and health devices
- Modeling: region and layer based modeling
 - Level of details (LOD1, LOD2, and LOD3)
 - Region partitioning and landmarks
 - Layer definition
- Animation: region and layer based deformation
 - Definition of deformation parameters
- Interface with medical and health devices
 - Definition of information from devices
 - Meta information related to specific parts of an organ

Conclusions (2)

- Standards development (ISO/IEC JTC 1/SC 24/WG 6)
 - Human internal organ representation and data model (Part 1)
 - Human respiratory system representation (Part 2)
 - Human digestive system representation (Part 3)
 - Human circulatory system representation (Part 4)
 - Human urinary system representation (Part 5)