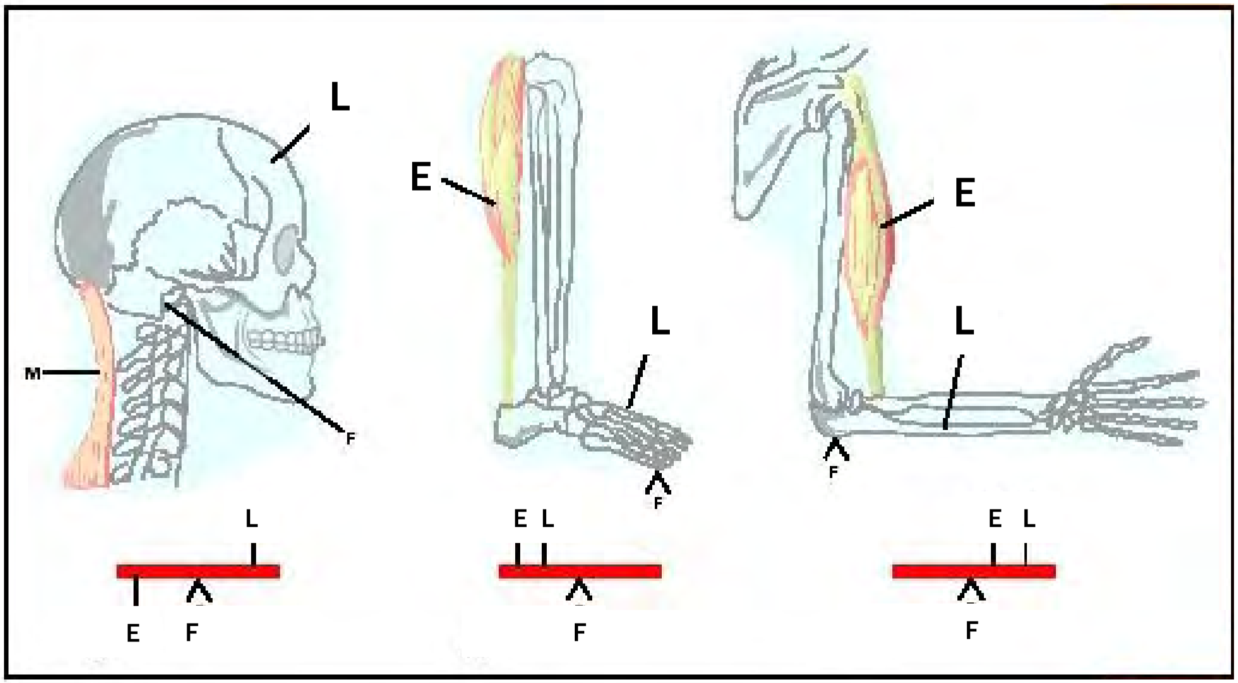
# ROTATIONAL EQUILIBRIUM

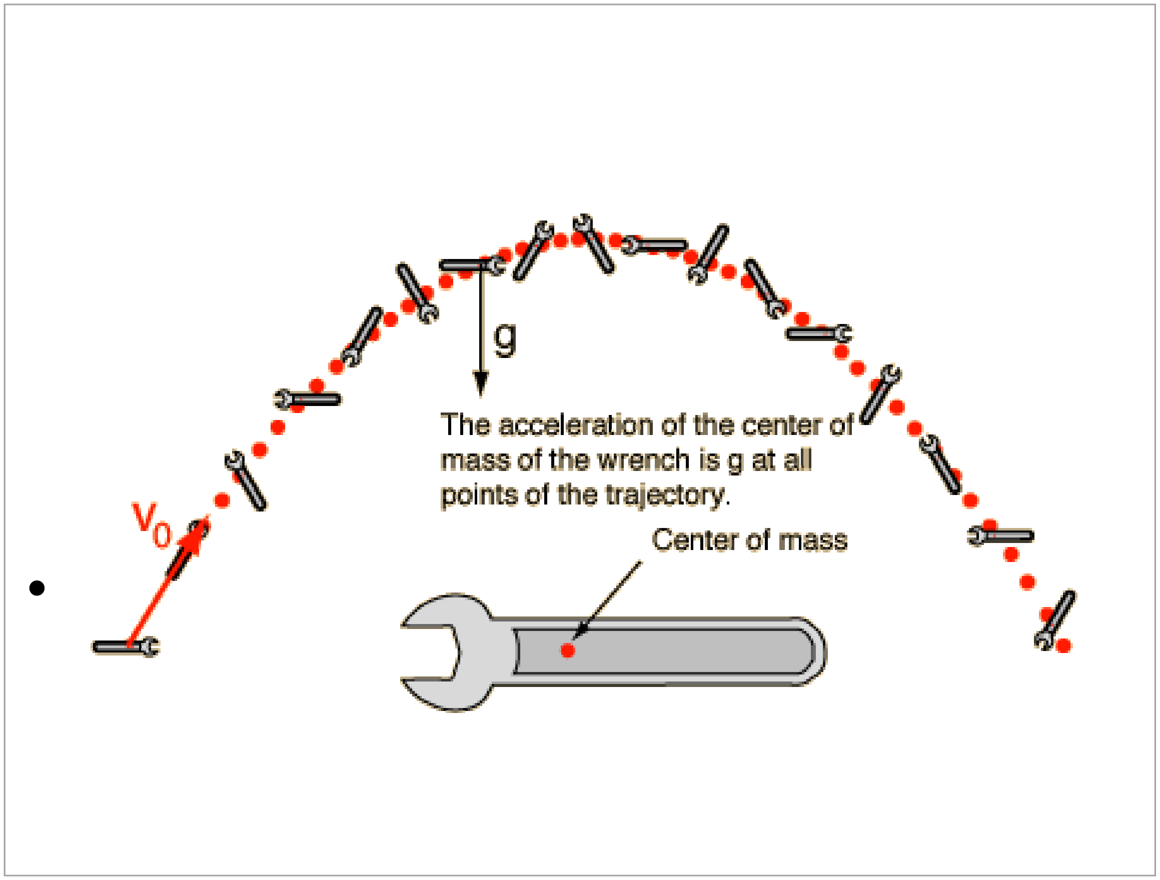
# ROTATIONAL DYNAMICS



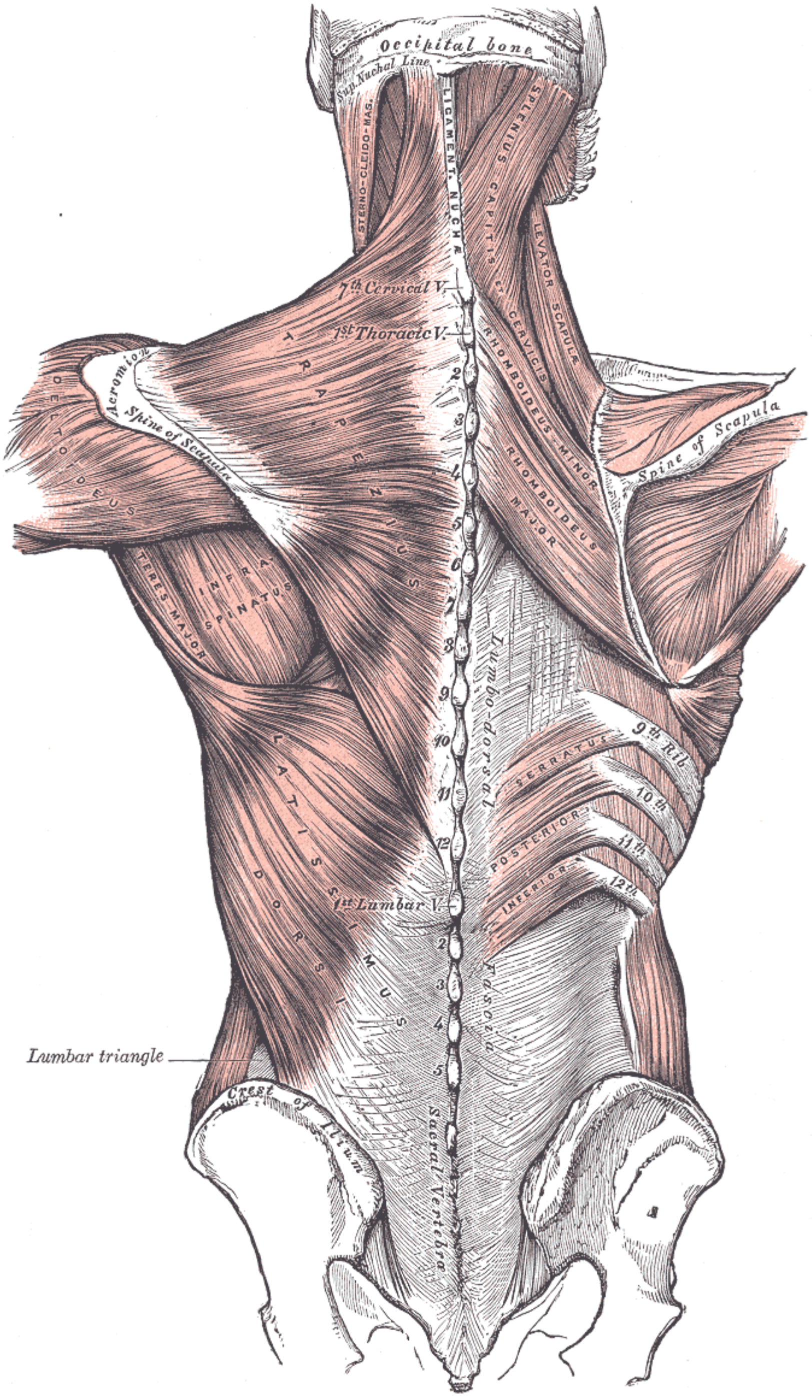


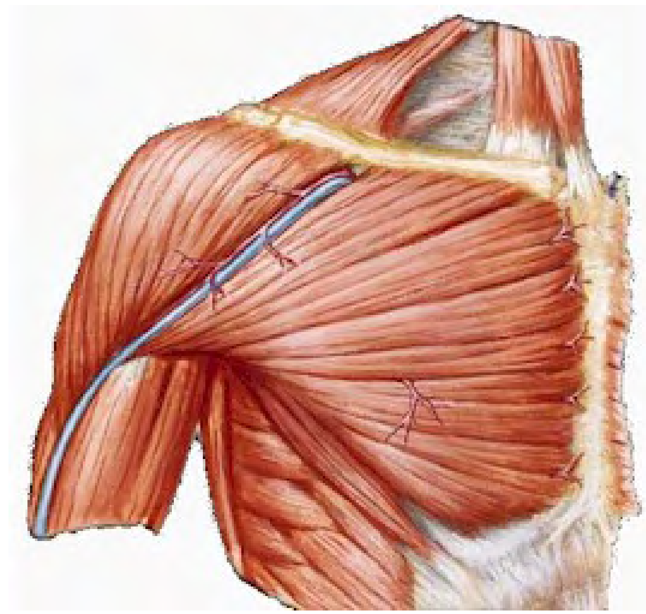

Classes of levers.
(a) In a first-class lever, the fulcrum (F) is set up between the load (L) and the effort (E).
(b) In a second-class lever, the resistance is between the fulcrum and the effort.
(c) In a third-class lever, the effort is between the fulcrum and the load.

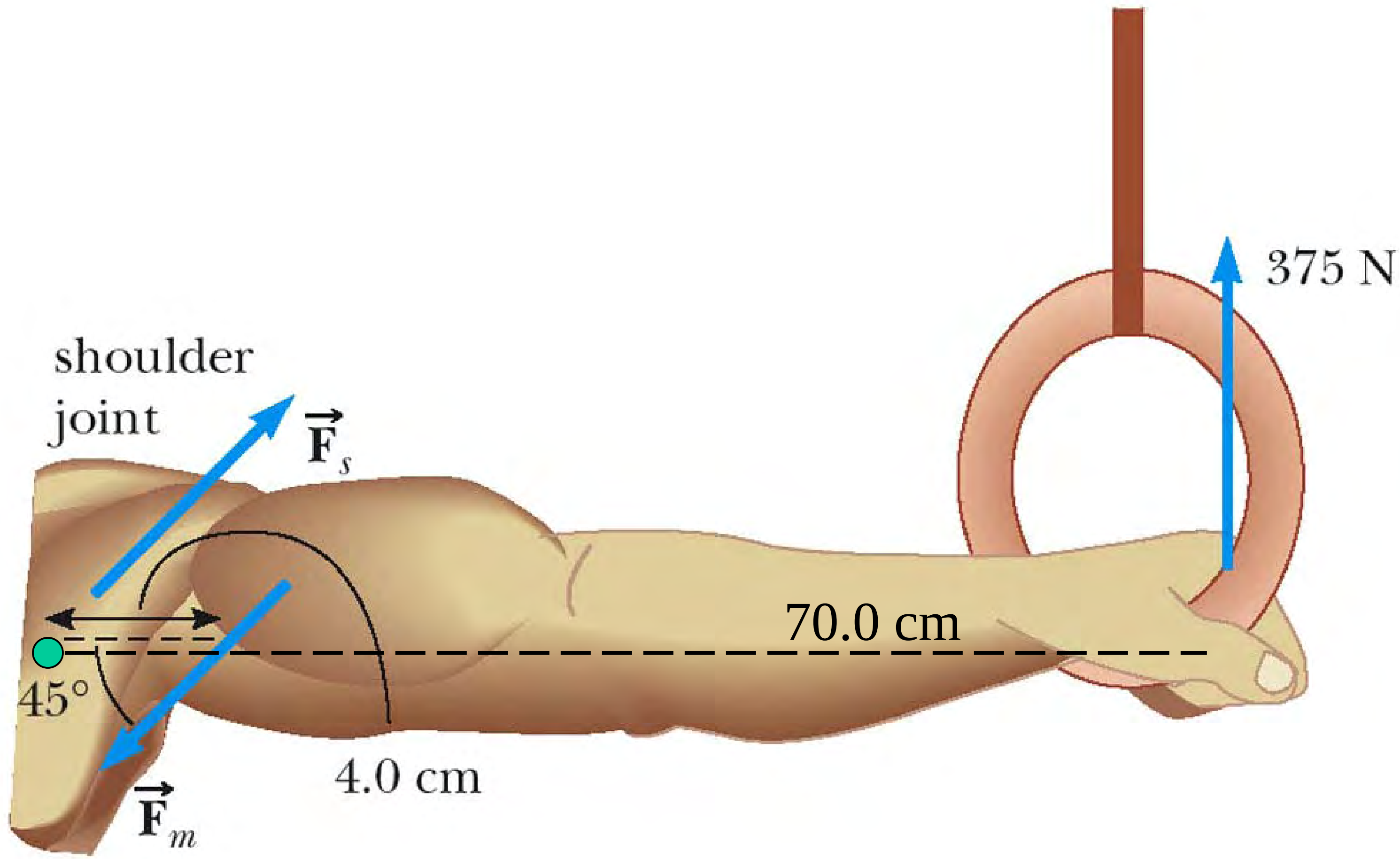


$v_0$
g
The acceleration of the center of mass of the wrench is g at all points of the trajectory.
Center of mass



Occipital bone
Sup. Nuchal Line
STERNO-CLEIDO-MAS.
LIGAMENT. NUCHÆ
SPLENIUS CAPITIS ET CERVICIS
LEVATOR SCAPULÆ
7th Cervical V.
1st Thoracic V.
TRAPEZIUS
RHOMBOIDEUS MINOR
RHOMBOIDEUS MAJOR
Acromion
Spine of Scapula
DELTOIDEUS
TERES MAJOR
INFRASPINATUS
Lumbo-dorsal
9th Rib
10th
11th
12th
SERRATUS POSTERIOR INFERIOR
LATISSIMUS DORSI
1st Lumbar V.
Fascia
Lumbar triangle
Crest of Ilium
Sacral Vertebræ





375 N
shoulder joint
$\vec{F}_s$
70.0 cm
45°
4.0 cm
$\vec{F}_m$

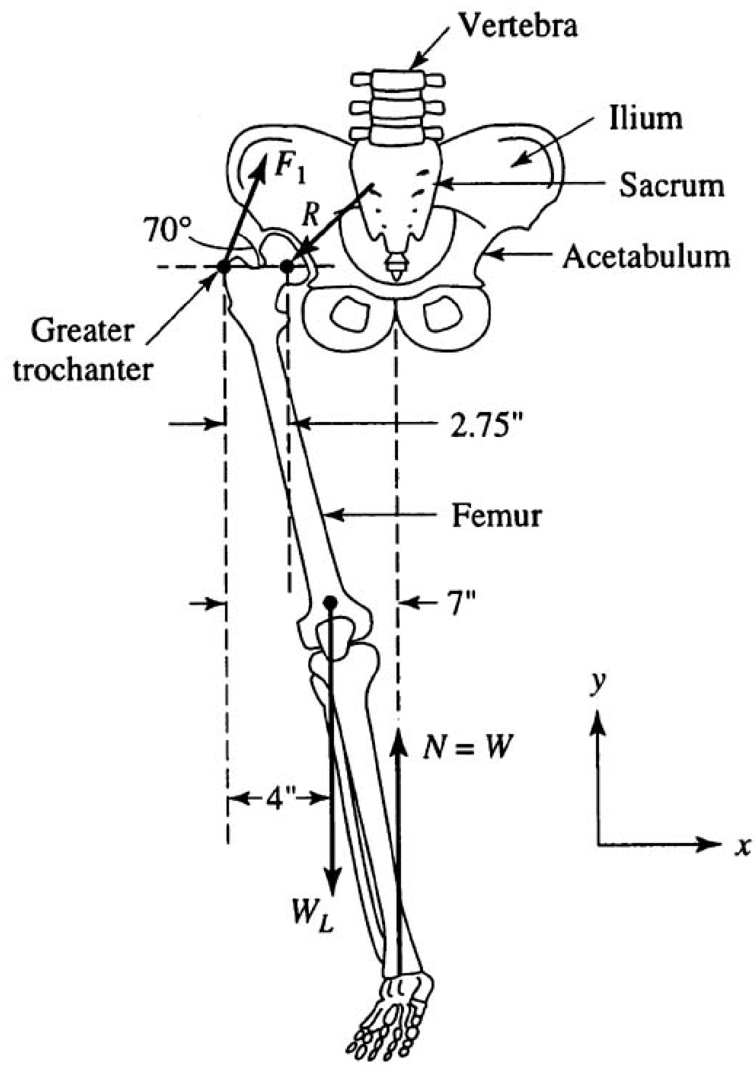



Figure 3.16. Anatomical sketch of leg and hip showing forces and dimensions. $R$ is the force that the acetabulum exerts on the head of the femur. $F_1$ is the net force exerted by the hip abductor muscles. (Redrawn from Williams and Lissner, [4].)

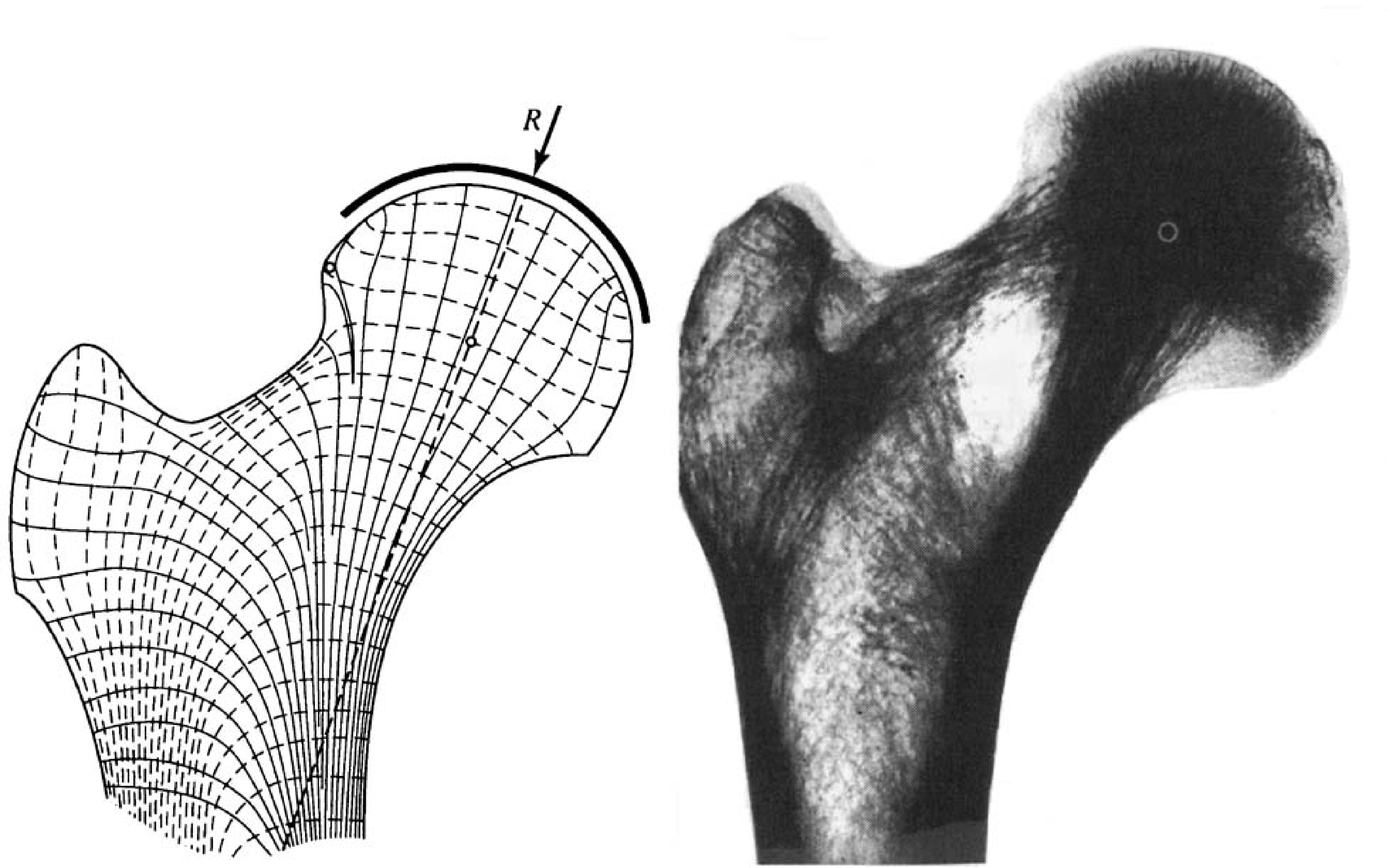



Figure 3.18. X-ray photograph of human femur.

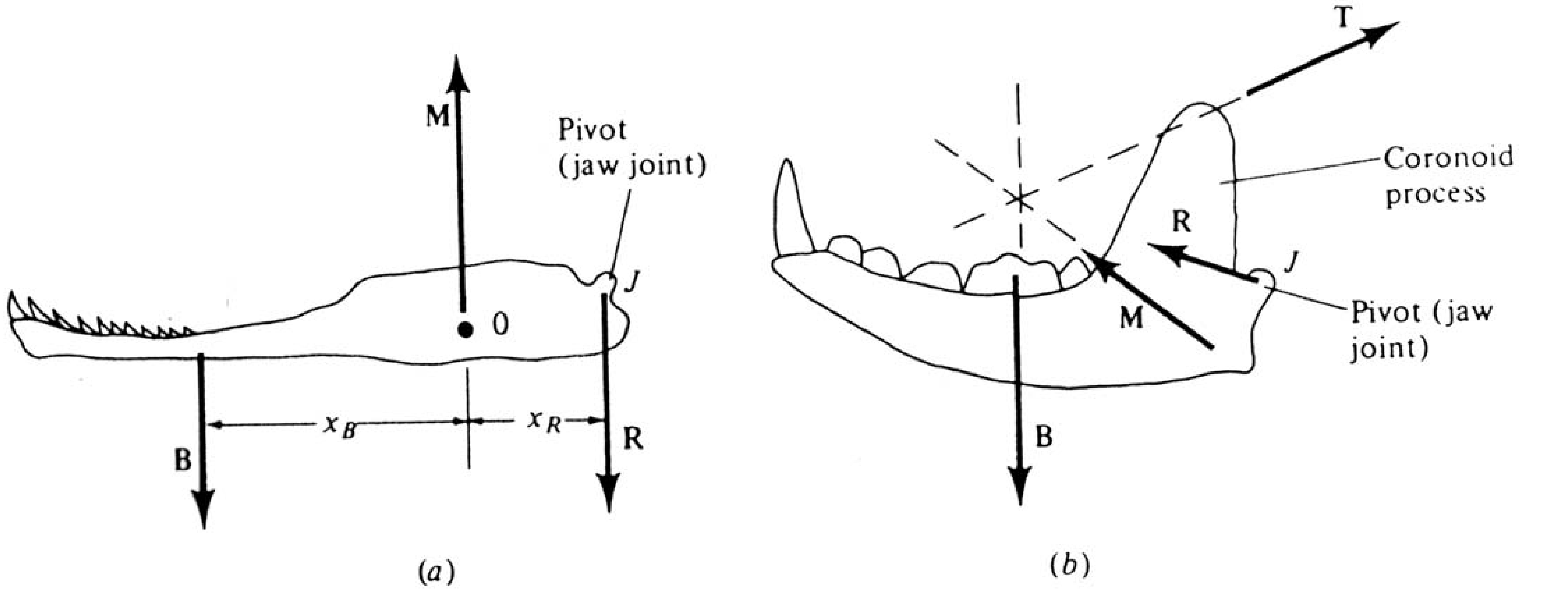
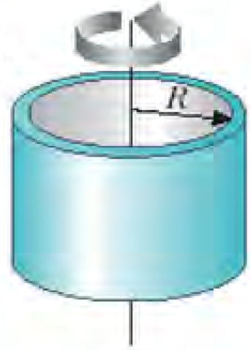



**Figure 4.62.** (*a*) Lower jaw of a primitive reptile. **M** is the force due to the muscle, **B** is the reaction force from the object being bitten, and **R** is the force due to the jaw joint at *J*. (*b*) A mammalian jaw. Muscle forces are shown as **T** and **M**. As explained in the text, the force **R** due to the jaw joint can be zero if the lines of action of the three forces **T**, **B**, and **M** intersect as shown here.

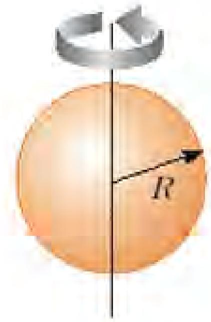
## TABLE 8.1

**Moments of Inertia for Various Rigid Objects of Uniform Composition**

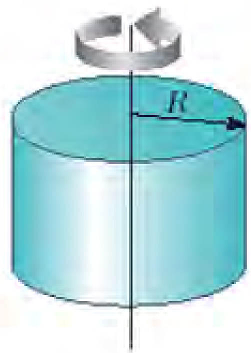
Hoop or thin cylindrical shell
$I = MR^2$



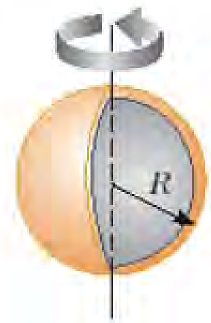

Solid sphere
$I = \frac{2}{5} MR^2$



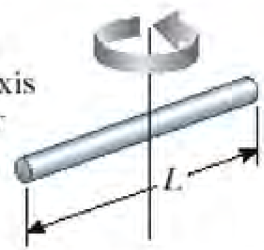

Solid cylinder or disk
$I = \frac{1}{2} MR^2$



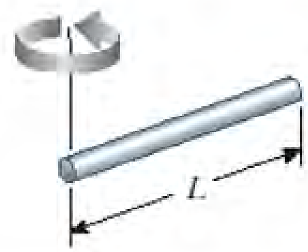

Thin spherical shell
$I = \frac{2}{3} MR^2$

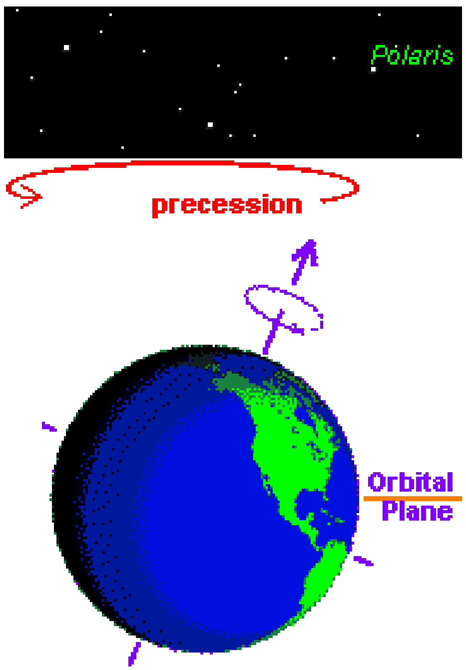



Long thin rod with rotation axis through center
$I = \frac{1}{12} ML^2$



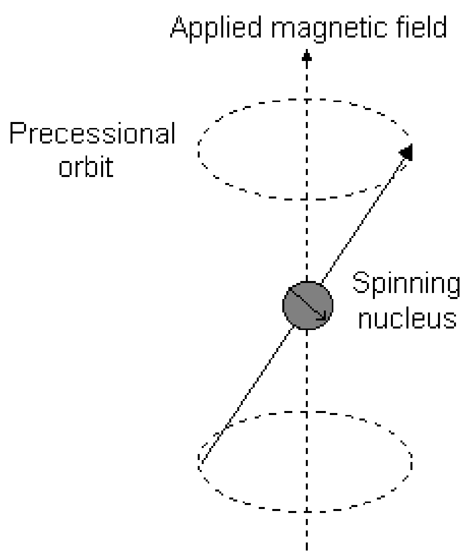

Long thin rod with rotation axis through end
$I = \frac{1}{3} ML^2$

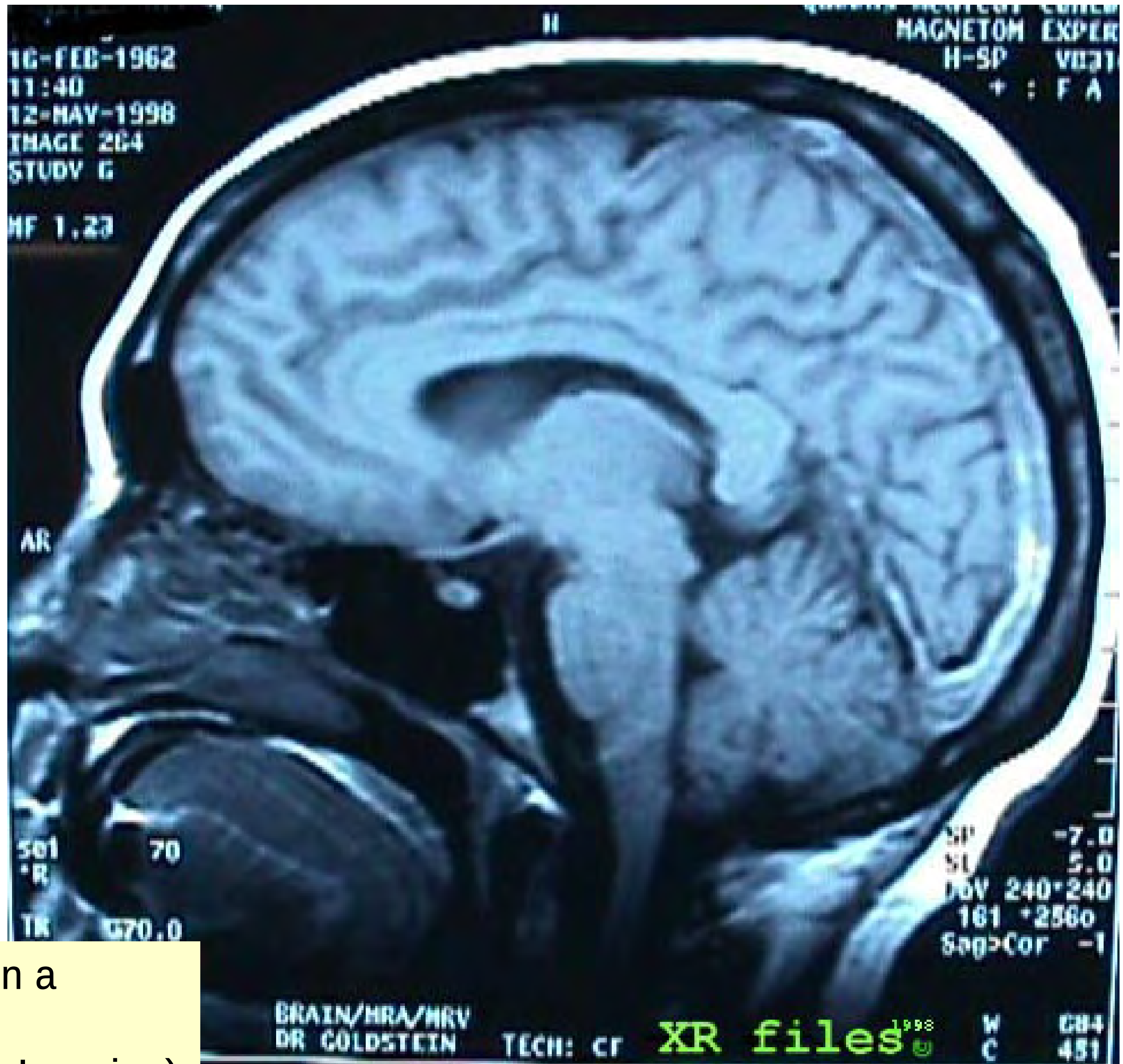




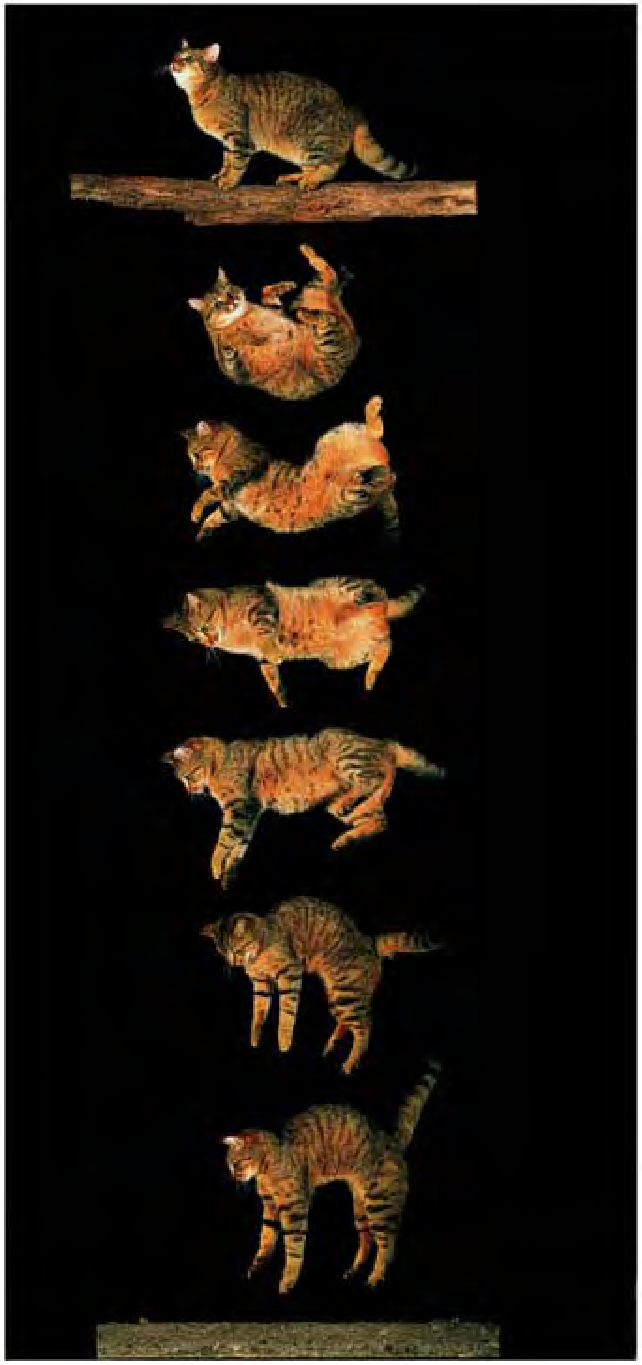


The north pole doesn't always point at the North star (precession)



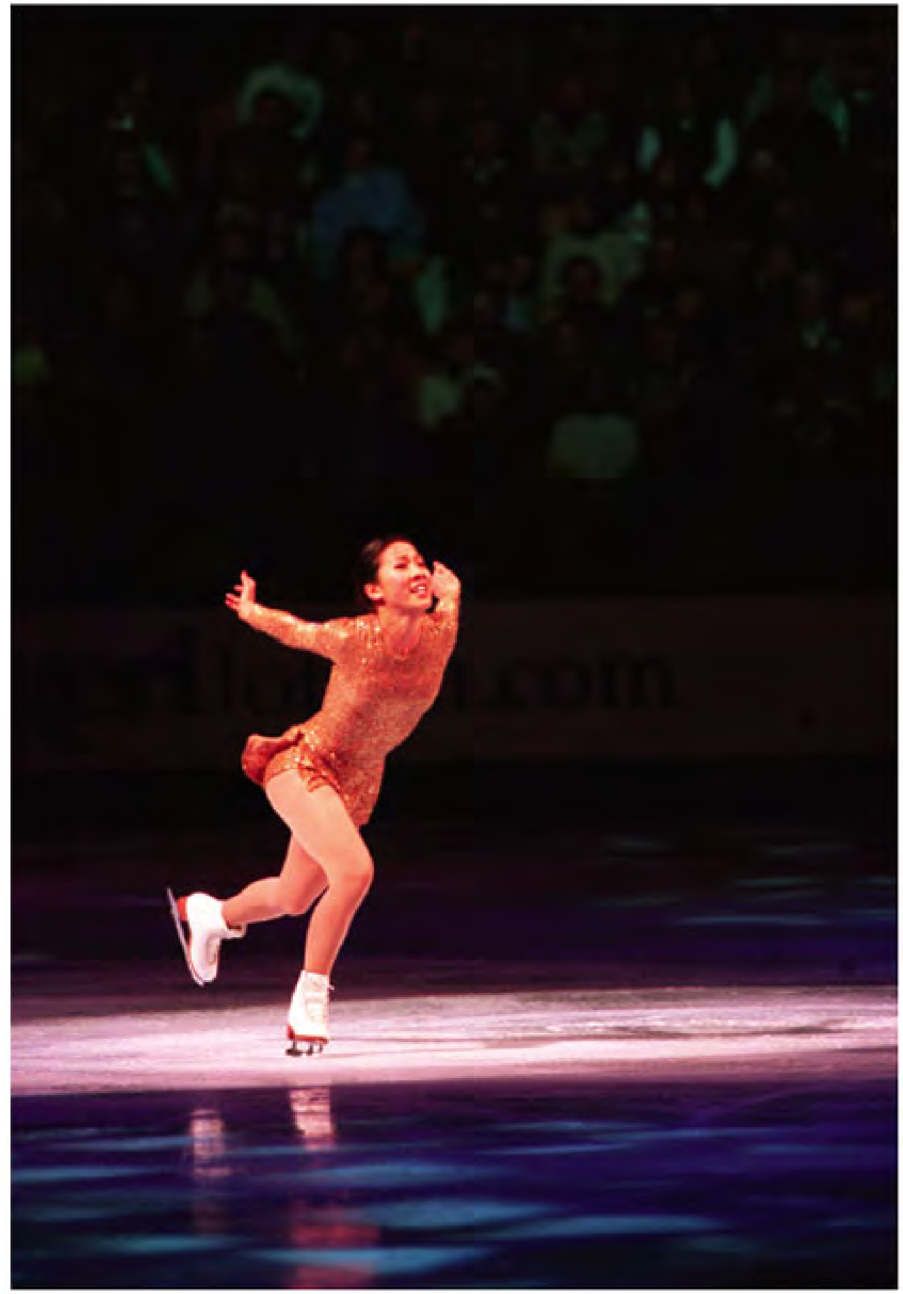

Precession of nuclei in a magnetic field = MRI (Magnetic Resonance Imaging)





Front legs tucked in, hind legs stretched out;
small $I_{front}$, big $I_{back}$ ---- twist chest and head

Front legs stretched out, hind legs tucked in;
big $I_{front}$, small $I_{back}$ ---- twist hindquarters



**No. 6** on USA TODAY's 10 hardest things to do in sports is landing a quad in figure skating. Here's why it's hard, from a scientific perspective, from an expert athlete's perspective and from an average joe's.

By Gary Mihoces
USA TODAY

By Robert Hanashiro, USA TODAY

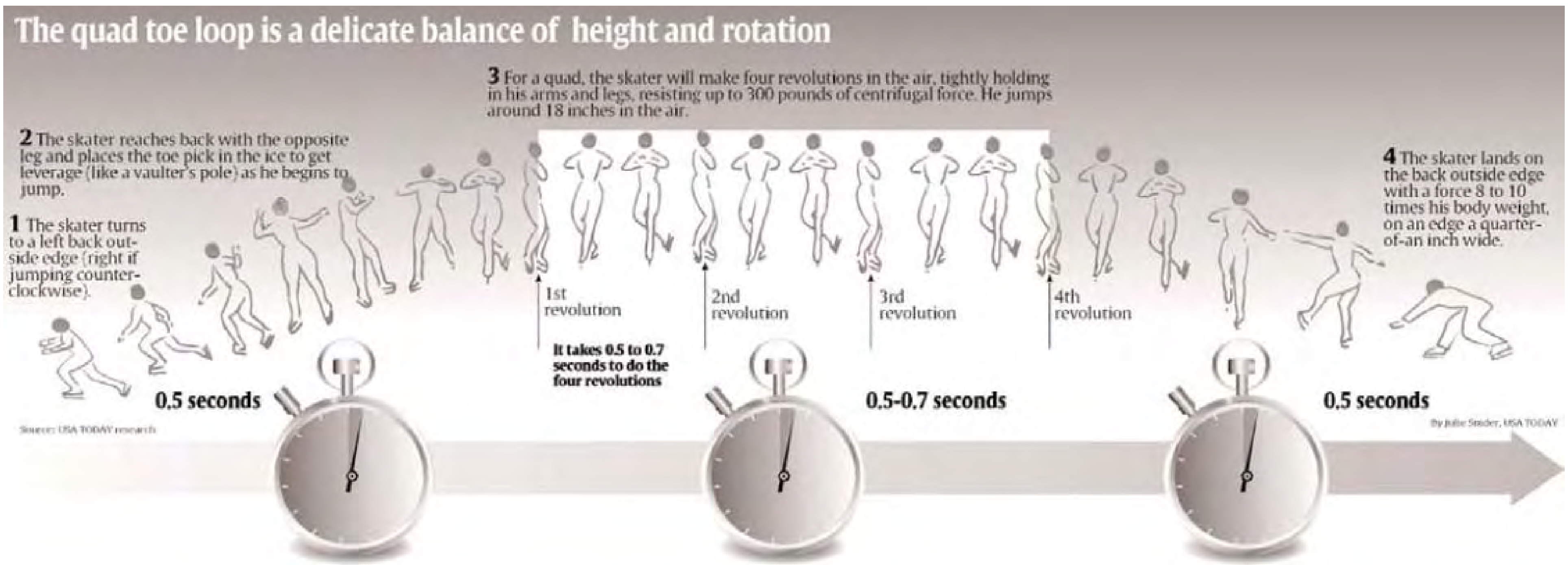
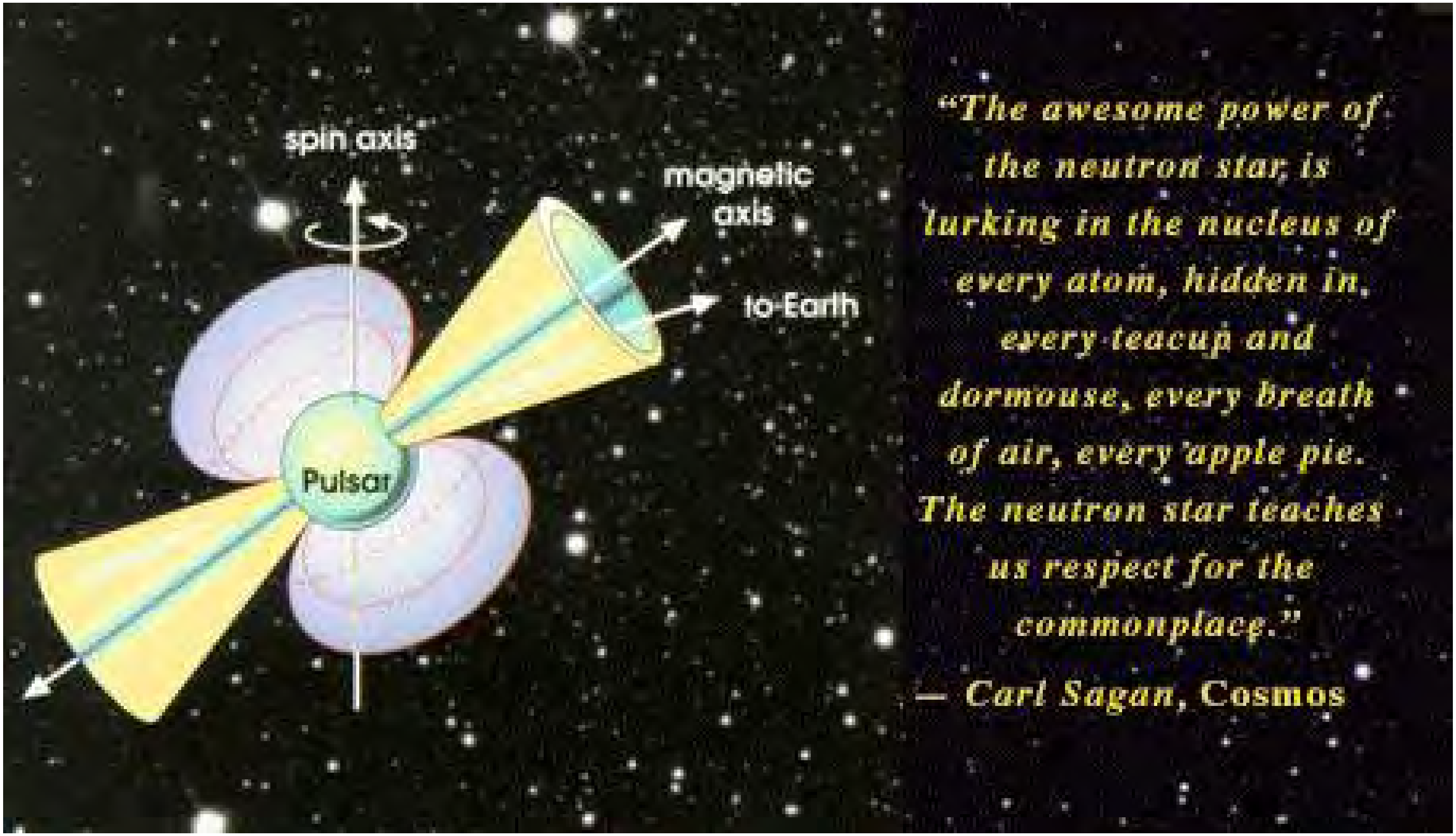


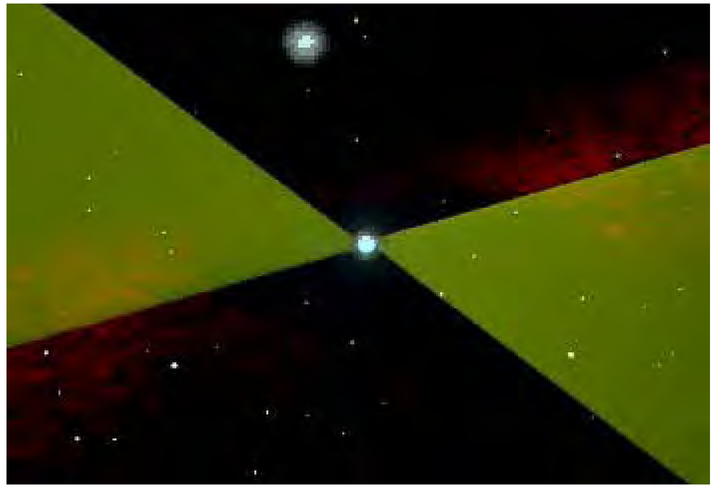
**Table 3.1 Anthropometric Data**

| Segment | Definition | Segment Weight/ Total Body Weight | Center of Mass/ Segment Length | | Radius of Gyration/ Segment Length | | | Density |
|---|---|---|---|---|---|---|---|---|
| | | | Proximal | Distal | C of G | Proximal | Distal | |
| Hand | Wrist axis/knuckle II middle finger | 0.006 M | 0.506 | 0.494 P | 0.297 | 0.587 | 0.577 M | 1.16 |
| Forearm | Elbow axis/ulnar styloid | 0.016 M | 0.430 | 0.570 P | 0.303 | 0.526 | 0.647 M | 1.13 |
| Upper arm | Glenohumeral axis/elbow axis | 0.028 M | 0.436 | 0.564 P | 0.322 | 0.542 | 0.645 M | 1.07 |
| Forearm and hand | Elbow axis/ulnar styloid | 0.022 M | 0.682 | 0.318 P | 0.468 | 0.827 | 0.565 P | 1.14 |
| Total arm | Glenohumeral joint/ulnar styloid | 0.050 M | 0.530 | 0.470 P | 0.368 | 0.645 | 0.596 P | 1.11 |
| Foot | Lateral malleolus/head metatarsal II | 0.0145 M | 0.50 | 0.50 P | 0.475 | 0.690 | 0.690 P | 1.10 |
| Leg | Femoral condyles/medial malleolus | 0.0465 M | 0.433 | 0.567 P | 0.302 | 0.528 | 0.643 M | 1.09 |
| Thigh | Greater trochanter/femoral condyles | 0.100 M | 0.433 | 0.567 P | 0.323 | 0.540 | 0.653 M | 1.05 |
| Foot and leg | Femoral condyles/medial malleolus | 0.061 M | 0.606 | 0.394 P | 0.416 | 0.735 | 0.572 P | 1.09 |
| Total leg | Greater trochanter/medial malleolus | 0.161 M | 0.447 | 0.553 P | 0.326 | 0.560 | 0.650 P | 1.06 |
| Head and neck | C7-T1 and 1st rib/ear canal | 0.081 M | 1.000 | — PC | 0.495 | 1.116 | — PC | 1.11 |
| Shoulder mass | Sternoclavicular joint/ glenohumeral axis | — | 0.712 | 0.288 | — | — | — | 1.04 |
| Thorax | C7-T1/T12-L1 and diaphragm* | 0.216 PC | 0.82 | 0.18 | — | — | — | 0.92 |
| Abdomen | T12-L1/L4-L5* | 0.139 LC | 0.44 | 0.56 | — | — | — | — |
| Pelvis | L4-L5/greater trochanter* | 0.142 LC | 0.105 | 0.895 | — | — | — | — |
| Thorax and abdomen | C7-T1/L4-L5* | 0.355 LC | 0.63 | 0.37 | — | — | — | — |
| Abdomen and pelvis | T12-L1/greater trochanter* | 0.281 PC | 0.27 | 0.73 | — | — | — | 1.01 |
| Trunk | Greater trochanter/ glenohumeral joint* | 0.497 M | 0.50 | 0.50 | — | — | — | 1.03 |
| Trunk head neck | Greater trochanter/ glenohumeral joint* | 0.578 MC | 0.66 | 0.34 P | 0.503 | 0.830 | 0.607 M | — |
| HAT | Greater trochanter/ glenohumeral joint* | 0.678 MC | 0.626 | 0.374 PC | 0.496 | 0.798 | 0.621 PC | — |
| HAT | Greater trochanter/mid rib | 0.678 | 1.142 | — | 0.903 | 1.456 | — | — |

*NOTE: These segments are presented relative to the length between the greater trochanter and the glenohumeral joint.

*Source Codes:* M, Dempster via Miller and Nelson; *Biomechanics of Sport*, Lea and Febiger, Philadelphia, 1973. P, Dempster via Plagenhoef; *Patterns of Human Motion*, Prentice- Hall, Inc. Englewood Cliffs, N.J., 1971. L, Dempster via Plagenhoef from living subjects; *Patterns of Human Motion*, Prentice-Hall, Inc., Englewood Cliffs, N.J., 1971. C, Calculated.

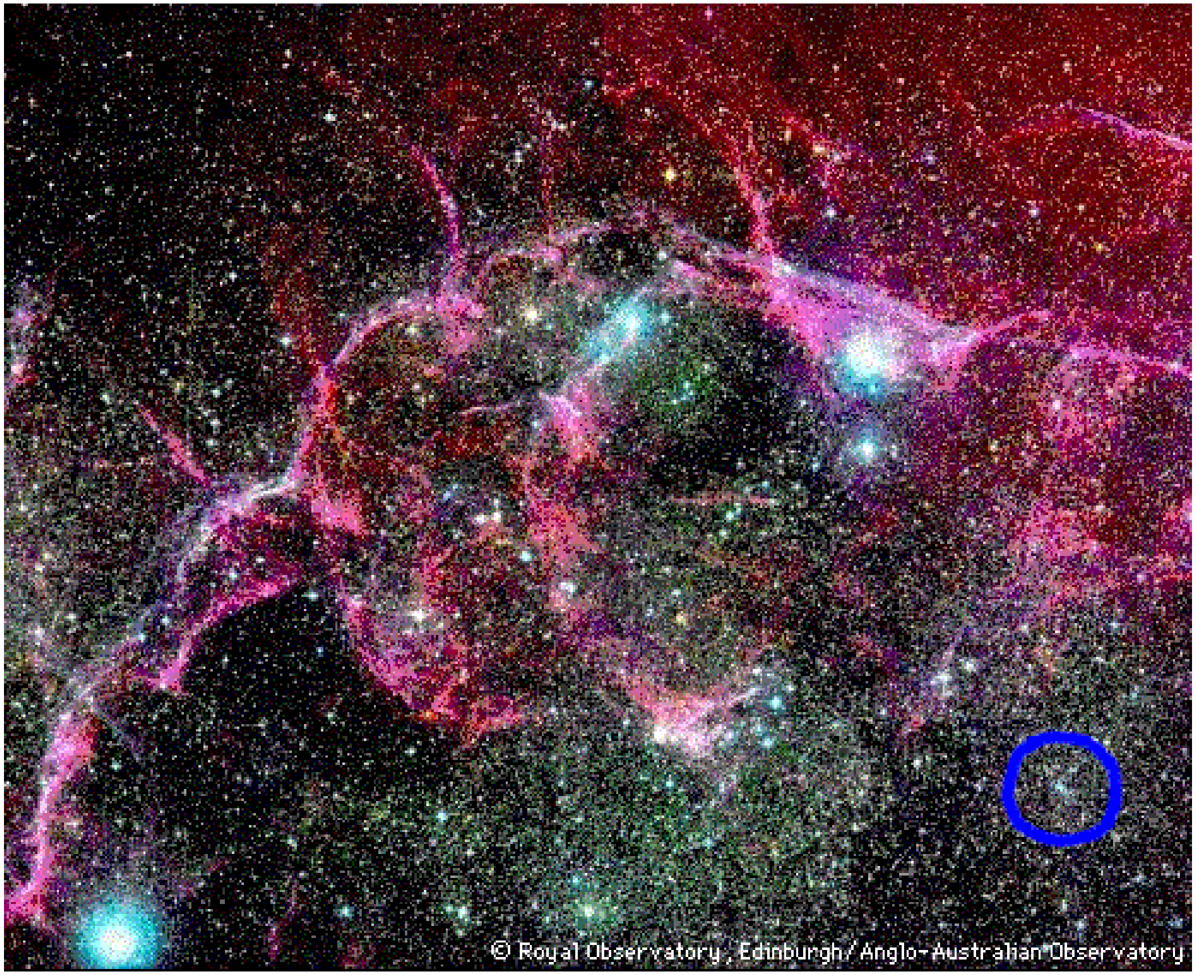

spin axis
magnetic axis
to Earth
Pulsar
"The awesome power of the neutron star is lurking in the nucleus of every atom, hidden in every teacup and dormouse, every breath of air, every apple pie. The neutron star teaches us respect for the commonplace."
– Carl Sagan, Cosmos



# PSR B0329+54

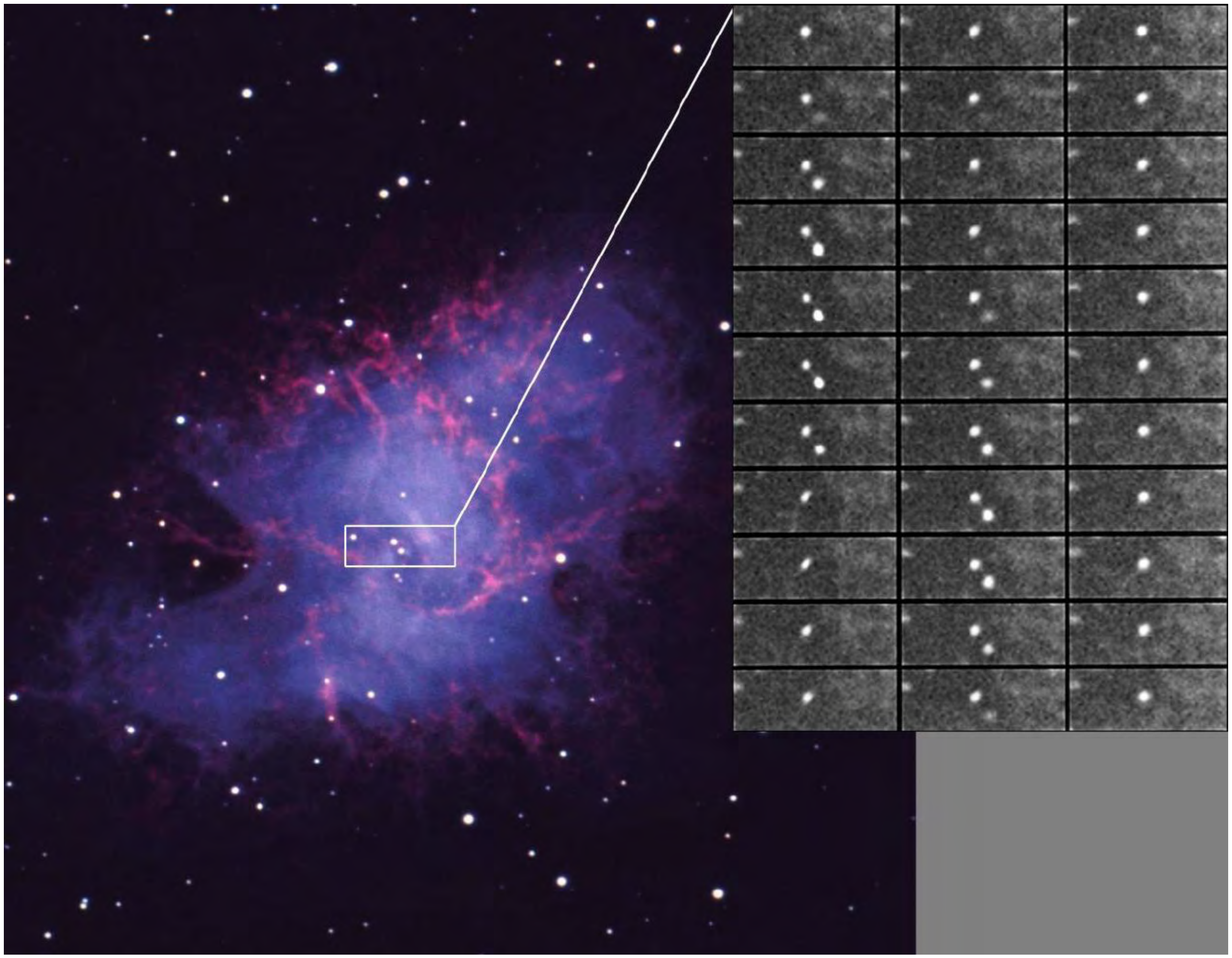
This pulsar is a typical, normal pulsar, rotating with a period of 0.714519 seconds, i.e. close to 1.40 rotations/sec.

# PSR B0833-45, The Vela Pulsar




This pulsar lies near the center of the Vela supernova remnant, which is the debris of the explosion of a massive star about 10,000 years ago. The pulsar is the collapsed core of this star, rotating with a period of 89 milliseconds or about 11 times a second.

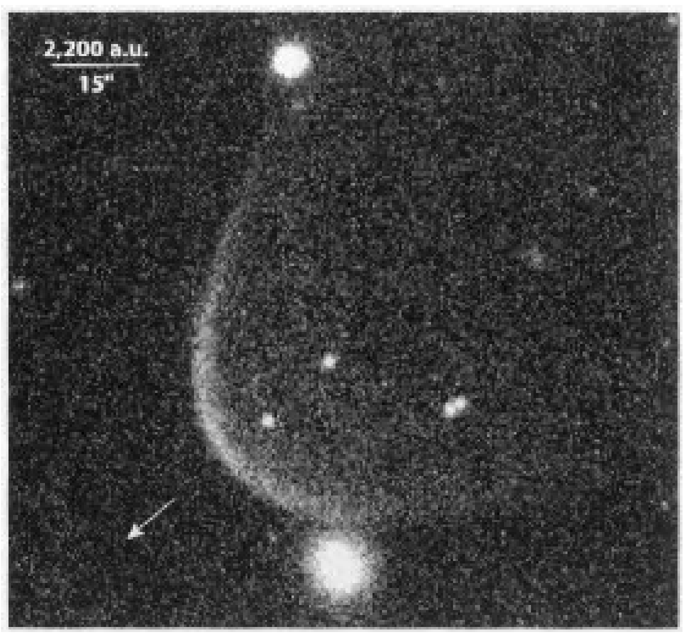
# PSR B0531+21, The Crab Pulsar



This is the youngest known pulsar and lies at the centre of the Crab Nebula, the supernova remnant of its birth explosion, which was witnessed by Europeans and Chinese in the year 1054 A.D. as a day-time light in the sky. The pulsar rotates about 30 times a second.

# PSR J0437-4715

This is a recently discovered millisecond pulsar, an old pulsar which has been spun up by the accretion of material from a binary companion star as it expands in its red giant phase. The accretion process results in orbital angular momentum of the companion star being converted to rotational angular momentum of the neutron star, which is now rotating about 174 times a second.



# PSR B1937+21

This is the fastest known pulsar, rotating with a period of 0.00155780644887275 seconds, or about 642 times a second. The surface of this star is moving at about 1/7 of the velocity of light and illustrates the enormous gravitational forces which prevent it flying apart due to the immense centrifugal forces.