Fossil Evidence

At a dig in Egypt a team of paleontologists, among them the University of Michigan's Philip Gingerich, found the nearly complete skeleton of a whalelike creature now called *Dorudon* (replica, opposite). Dating back 40 million years, it had a detached pelvis near the end of its tail and useless little legs. Like the human hand, an early whale's front foot (above right) retains a five-fingered bone structure; a vestigial rear foot (above left) has lost several toe bones, but its very existence testifies to the whale's descent from a four-legged ancestor. Illuminating but spotty, the fossil record is like a film of evolution from which 999 of every 1,000 frames have been lost on the cutting-room floor. Still, Gingerich and others have found dozens of intermediate forms—missing links that are no longer missing.
ADAPTIVE RADIATION:
MAMMALIAN FORELIMBS

- SCAPULA
- RADIUS
- HUMERUS
- ULNA
- CARPALS (WRIST)
- METACARPALS (HAND)
- PHALANGES (FINGERS)

**BAT**

**MOLE**

**HUMAN**

**WOLF**

**OPPOSUM**

**ELEPHANT**

**SEA LION**
Anatomy: Analogous Structures

CONVERGENCE: THE SWIMMING NICHE

BODY SHAPE:

FORELIMP:

FISH (SHARK):
LIMP SUPPORT:

REPTILE (ICHTHYOSAUR):
LIMP BONES:

BIRD (PENGUIN):
LIMP BONES:

MAMMAL (DOLPHIN):
LIMP BONES:
Most mammals have a well-developed tail, but this is lacking in apes and humans. Still, the tail is represented by the last three to five bones in the backbone of humans. Even though an external tail usually is not present, the muscles that move the tail in other mammals also are present in humans, and on rare occasions, a fleshy tail in a human extends a few inches beyond the caudal vertebrae.

Blind salamanders. These salamanders from Arkansas and Missouri have become adapted to life in deep caves where sunlight never reaches. They possess eyes, but their eyes do not function; they are blind.

Snakes with legs. Notice the bony parts of the python's pelvic girdle to which tiny limb bones attach. The legs serve no function.

Additional evidence for biological change and the relatedness of different organisms comes from the study of comparative anatomy, which is the branch of biology that concentrates on the similarities and differences in anatomical features of different species. In making such comparisons, scientists have discovered structures that are functional in some species, but seemingly useless in others. We refer to these dwarfed or apparently useless structures as vestigial, which comes from the word vestige, meaning "a remnant of." The "goose bumps" that you get when you are cold are an example of vestigial structures. Goose bumps are produced by the concentration of erector pilae muscles in the skin. In other mammals and birds, the contraction of erector pilae muscles causes the fur or feathers to fluff up. This mechanism helps the organism warm up. Humans have not retained very much hair, but we have retained the erector pilae muscles. Figure 2.4 shows three more examples of vestigial structures.

Although there is abundant evidence for the unity of all life on earth, it also is evident that life forms are very diverse. How did this diversity come about? Even short-term observations can support the view that the average characteristics of a species gradually change. For example, biologists made measurements of finches isolated on an island, the Galápagos Archipelago, during a period of 10 years. Gradual increases occurred in the average size of birds along with the thickness of their beaks, particularly following two extreme droughts. These results support the idea that species' characteristics can and do change gradually.
DNA HYBRIDIZATION

HUMAN DNA

CHIMPANZEE DNA

COMPLEMENTARY BASES

NONCOMPLEMENTARY BASES

MELTING TEMPERATURE

"HYBRID" DNA
COMPARATIVE EMBRYOLOGY

ONTOGENY AND PHYLOGENY

FERTILIZED EGG
LATE CLEAVAGE
BODY SEGMENTS FORM
LIMB BUDS APPEAR
LARVAL FORM/LATE FETAL
NEWLY HATCHED: NEWBORN: ADULT

HUMAN

MONKEY

PIG

CHICKEN

SALAMANDER

GILL SUC
UMBILICUS
SHOLL BREAKER
LARVAL FORM
METAMORPHOSIS